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Art. XXIX.—Benjamin Peirce.*

Benjamin Peirce was born in Salem, Mass., on the 4th day of April, 1809, and he died at Cambridge, on the 6th day of October, 1880.

In his early years he had the good fortune to come under the influence of Doctor Nathaniel Bowditch. It is said that their first acquaintance was made while Dr. Bowditch's son Ingersoll and young Peirce were schoolmates. Ingersoll showed his comrade a solution which his father had prepared of a problem that the boys had been at work upon. Some error, real or conceived, was pointed out in the work, which was reported by Ingersoll to his father. "Bring me that boy who corrects my mathematics!" was the invitation to an acquaintance, the importance of which in Professor Peirce's own estimation is told in the dedication, more than thirty years later, of his "Analytic Mechanics" "to the cherished and revered memory of my Master in Science, Nathaniel Bowditch, the father of American Geometry."

Peirce entered Harvard College in 1825. As Doctor Bowditch was now in Boston, having removed from Salem in 1823, and was preparing the first volume of his translation of Laplace's "Mécanique Céleste" for the press, it followed almost as a matter of course that the college student was more influenced in his studies by him than by the college course. Doctor Bowditch's first volume was completed and the second entered for

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copyright in 1829, the year of Peirce's graduation, and the proof-sheets were regularly read by him.

After graduation, two years were spent by Professor Peirce in teaching at Northampton. In 1831 he was appointed Tutor in Harvard College, and in 1833 was made Professor of Mathematics and Natural Philosophy.

The earlier years of his professorship were fruitful as to publication, principally in a series of text-books for use in college. The first that appeared were treatises on "Plane and Spherical Trigonometry" in 1835 and 1836, which were published in a more complete form, with a "Spherical Astronomy," in 1840. Next came a "Treatise on Sound," in 1836, which was based upon Herschel's work in the "Encyclopædia Metropolitana," but with very important changes. The bibliography of the subject in the Introduction is of permanent value. This was followed, in 1837, by his "Plane and Solid Geometry," and by a "Treatise on Algebra."

A work on "Curves, Functions and Forces" was begun in 1841 by the publication of a volume on "Analytical Geometry and Differential Calculus." A second volume, on the "Calculus of Imaginaries, Residual Calculus, and Integral Calculus," appeared in 1846. As the word "forces" in the title shows, he intended to complete this work by a third volume on the "Calculus of Variations, and on Analytical Mechanics, with its Applications," but in this form it was never done.

Instead of this, however, and so to be mentioned in this place, though not properly a text-book, there appeared in 1855 the "Analytic Mechanics" in a quarto form, a work that more adequately expresses Professor Peirce's peculiar power than any other of his productions, with perhaps one exception.

In all of these books he departed not a little from the beaten path. In geometry the idea of direction was made the basis of the theory of parallels. Infinites and infinitesimals are introduced, along with the axiom, "Infinitely small quantities may be neglected." The demonstrations are given only in outline, being in respect of fulness the entire opposite o Euclid. A like brevity is characteristic of the other books, and in fact of everything mathematical that Professor Peirce ever wrote. He used a notation to which he gave much thought, by which his formulas were more concise than they could easily be made with the usual symbols. The Integral Calculus was at the period of its appearance much in advance of similar works, especially in the treatment of differential equations. It is an excellent example of Professor Peirce's concise and logical style.

The "Analytic Mechanics" was rather a treatise than a text-book. In it Professor Peirce set forth the general principles and methods of the science as a branch of mathematical theory,

and embodied in a systematic treatise the latest and best methods and forms of conceptions of the great geometers. He aimed to reduce them to their utmost simplicity by freeing them from every superfluous element. He made free use of the idea of the *potential*, developing nearly the whole subject from it. Determinants are used regularly as a standing instrument of analysis, and especially in the integration of the differential equations of motion. Both of these features, as well as Jacobi's method of integration by his principle of the last multiplier, were at the time new in English treatises.

The whole volume is marked by a directness of thought and a brevity of expression which make it difficult reading for those who have been accustomed only to the usual forms of notation and reasoning, and who do not read the book in course from the beginning. Several of the chapters are made peculiarly interesting by the development of a large number of special problems as particular cases of general theorems. In his later years the author often said he wanted to rewrite the "Analytic Mechanics" and introduce quarternions into it.

In 1842 Professor Peirce published, in connection with Professor Lovering, four numbers of the "Cambridge Miscellany," a quarterly journal devoted to mathematics, physics and astronomy.

In the same year he assumed the care of the mathematical part of the "American Almanac," ten volumes of which were prepared by him. In one of these (1847) he published a list of the known orbits of comets, arranged in convenient form, to which he added to the usual cometic catalogue several approximate orbits computed by him for historic comets that had been imperfectly observed.

In 1849 Congress established a Bureau for the publication of the "American Ephemeris and Nautical Almanac," under the superintendence of Lieutenant (afterwards Admiral) Davis. Professor Peirce was at once appointed Consulting Astronomer. In this capacity he prepared and published, in 1853, his "Tables of the Moon," which have been used in making the "Ephemeris" up to the volume for the year 1883. In coöperation with Lieutenant Davis, he designed the form and general plan of the Ephemeris, and he decided upon all the coefficients to be used. He commenced a revision of the theory of the planets, especially the four outer ones; but this seems not to have been carried to serviceable results, if we except certain separate communications to this Academy. He retained the position of Consulting Astronomer until 1867. The high place which the "American Ephemeris" has ever held among like publications owes much to the character given to it by Professor Peirce in these its earliest years.

When, in 1846, Galle discovered the planet Neptune in the place pointed out to him by Leverrier, Professor Peirce took the liveliest interest in the admirable researches of Leverrier and Adams. He entered with zest into all the questions which were thus raised. What is the orbit of the new planet? What its mass? How much do they differ from the assigned orbits and masses? Does the new planet explain all the irregularities of Uranus? Did the data lead necessarily to the assigned place, and to it alone?

The results of his investigations were at various times given to this Academy, but more especially on the 4th of April, 1848. He then gave the perturbations of longitude and radius vector of Uranus by Neptune, and announced that Neptune and either of the two hypothetical planets of Leverrier and Adams would equally explain the observations of Uranus, within reasonable limits of error.

Leverrier had proposed to himself to solve the following problem:—From the observed irregularities of the planet Uranus to compute the elements of the orbit of an assumed exterior planet that has caused these irregularities. He ought perhaps to have limited himself to the other problem, to which he gave so correct an answer, Where among the stars astronomers must look in order to see the disturbing body. The elements of the orbit could be had from observations when once the planet was seen. He found for the unknown planet an orbit and a mass by processes that will always command the admiration of men; and the place in that orbit, as is well known, was less than one degree, as seen from the earth, from the actual place where Galle found Neptune.

Yet Professor Peirce declared that Leverrier's geometric planet and Neptune were not the same bodies. He praised without question the work of Leverrier and of Adams, asserting for them their right to all the praise and *éclat* which the world had given them. But Leverrier had distinctly stated that the planet which disturbed Uranus could not be at a less mean distance from the sun than 35; that is, that no planet that was within this distance could cause the observed irregularities of the motion of Uranus. Neptune, however, is at a distance of only 30, and does account for the perturbations of Uranus.

In this and in other communications Professor Peirce claimed that the perturbations changed their character at the points where the mean motions had the ratios 2 : 5 and 1 : 2, and that the reasonings of Leverrier were thereby vitiated. Not a little controversy has come from these papers of Professor Peirce; and we cannot say that the last word in regard to the question has even yet been spoken. As is not unusual in like discussions, there is probably a portion of truth and a portion of error

with either party. Leverrier and Adams each, as Professor Peirce has himself shown, by his own laborious researches, did point out correctly a place where a planet should be looked for, and assigned paths which that planet could have been traveling for more than one hundred and twenty years previously, and have caused the observed irregularities. Yet the elements of that planet's orbit and its mass and those of Neptune differ widely enough to justify the assertion that for the latter *they* were not correctly given.

On the other hand, astronomers will not probably agree with Professor Peirce in regarding the change of character of the perturbations when the mean motions of the new planet and of Uranus pass through the exact ratios 2 : 5 and 1 : 2 as of vital importance. In the usual form of development these fractions do indeed make certain terms infinite. That belongs, however, to the form of the development, not to the perturbations. In solving the question, "Where is the disturbing body?" the solution need not have involved these forms; and it has not been shown that they entered into the work of either Leverrier or Adams in such a way as to vitiate it.

That the problem was really indeterminate has been steadily held by Professor Peirce. In January, 1878, he read to this Academy a paper, which has not been published, and the conclusions of which, therefore, will not compel the assent of astronomers until some one else shall have gone over the same questions. He showed a chart of the plane of the ecliptic with the orbits of Uranus and Neptune, and having those parts of the plane shaded within any part of which a planet of arbitrary mass might have been situated in September, 1846, and yet have caused, in the preceding years, the observed irregularities in the motions of Uranus, within reasonable limits of error. With a circular orbit, a large fraction (more than one half) of the ecliptic, as seen from the earth, contained some of the shaded portions. If an eccentricity not greater than one-tenth be allowed, the region was greatly enlarged. While, therefore, the solutions of Leverrier and Adams gave a place and a path that explained the disturbances, the problem in its nature was not, he claimed, one having a single answer, or even a finite number of answers.

In 1852, Professor Bache, then Superintendent of the United States Coast Survey, induced Professor Peirce to take up the subject of the longitude determinations in the Survey. As a result, there appeared in the successive volumes of the "Coast Survey Reports," communications from him upon the several questions that arise in the treatment of that subject. The most noteworthy referred to the determination of our longitude from Greenwich, since local differences were determined by the tele-

graphic method. The whole subject of errors of observations, the law of facility of error which is assumed in the method of least squares, its limits and defects, and the habits of observers, were carefully examined. The method of occultations was decided to admit of greater accuracy than any other that was then available, and the occultations of the Pleiades to furnish the most convenient means of its application. Formulæ and tables were prepared, old observations collected, and new ones made to apply this method. The question of our longitude is now, thanks to the ocean telegraph, one of history; but the questions of errors in observing, which Professor Peirce so thoroughly treated, will always be of practical import.

It seems as though there was a connection between this engagement with the Coast Survey and the appearance, in July, 1852, in Gould's "Astronomical Journal," of an article by Professor Peirce, entitled, "Criterion for the Rejection of Doubtful Observations." His object was to solve this problem: There being given certain observations, of which the greater part is to be regarded as normal, and subject to the ordinary law of error adopted in the method of least squares, while a smaller unknown portion is abnormal, and subject to some obscure source of error, to ascertain the most probable hypothesis as to the partition of the observations into normal and abnormal. This method or rule given for deciding whether an observation had better be left out of account has received the name, "Peirce's Criterion," and must be regarded as one of his best contributions to science. Tables for use in applying it were soon afterward published by Dr. Gould.

The "Criterion" has been criticised by Professor (now Sir G. B.) Airy as defective in its foundation and illusory in its results; and he was even of opinion that no rule for the exclusion of an observation can be obtained by any process founded purely upon a consideration of the discordance of those observations. This position of the Astronomer Royal must be regarded as entirely untenable; for no observer hesitates to call a widely discordant observation a mistake, and to reject it (when he can find no other reason for so doing), simply because of that discordance. What the mind thus instinctively does, there must be basis at least for a rule for doing. Professor Airy's objections were answered by Professor Winlock at the time of their appearance. The "Criterion" has been used considerably in this country, though not, perhaps, in Europe. The uniform testimony of our computers is, we believe, that it has given excellent discrimination, and that it does not come into conflict with proper judgment based upon experience. This shows the good working of it in actual practice.

That the "Criterion" has not come into use in Europe may

in some degree have been due to the excessive brevity of the argument by which Professor Peirce established the equations to be used. Perhaps no one has read that argument for the first time without finding difficulty in understanding some parts of the reasoning. A want of confidence may thus have easily resulted. Professor Chauvenet has given us a simpler rule for use in rejecting a single divergent observation; but it is only an approximate solution, since one important element is left out of account. Computers need some such rule to guide them, and it would seem almost certain that "Peirce's Criterion," or possibly some modified form of it, will in time secure general acceptance. In any case, it will ever stand as the first, and as a satisfactory, solution of this delicate and practically important problem of probability. At present it is the only solution we believe that claims to be complete.

After the death of Professor Bache, Professor Peirce was, in 1867, made Superintendent of the United States Coast Survey, and he discharged the duties of that office for the next seven years. Soon after his appointment he made a tour of inspection among the parties at work in the field. Notwithstanding his previous intimate relations with the survey as adviser to Professor Bache, he was very much surprised and delighted with the practical skill which many of the officers had acquired. "I recognize at once," he said, "the masters of the profession." Unfortunately, he recognized also the awkward and inefficient, and the presence of these, which even the admirable executive abilities of his predecessor had not been able to eliminate, gave him great concern. Yet he determined to hold to the broadest line of policy, and introduce no rigid discipline that might damp the ardor and spontaneity of the faithful. "The lame and the lazy are always provided for," says the adage; and in the public service they are found, practically, to have the most friends from without, because needing them most. In a scientific service like the Coast Survey, which, unlike many of the departments of the civil service, furnishes absolute criteria from which to judge the merits of an officer, the task of discrimination, if undertaken by a superintendent well versed in the mathematics and physics underlying the manœuvres of the surveyor, would seem to be as easy as it is just. But it was a saying of Professor Bache, that "it would be easy enough to crush directly the men who betrayed the good repute of the service if it was not for uncles, aunts, and cousins, who proposed, in their turn, to crush him."

It was after his return from one of his earliest tours of inspection that Professor Peirce, in conversation with one of the older assistants, said he proposed to give, at least at the outset, greater freedom of action to the officers of the corps, that each

might indicate the full scope of his powers and receive promotion, or give place to another according as the results of his work might determine. "The office," he said, "can add nothing to my reputation unless I can give it greater dignity by raising the standard of the service. I mean to bring the best men to the front and secure publicity to their merits, that they may feel directly responsible to the community and do their utmost for its approbation. To become the leader of a corps of distinguished men is the best thing I can do for the country, for the men themselves, and for my own reputation." This was the policy which he initiated in the Coast Survey, and its wisdom was demonstrated at once. A very large proportion of the officers appreciated his motives, caught the enthusiasm of his genius, and found a new delight in serving a master who coveted nothing, but with rare simplicity lent his own strength to secure to them the full rewards of their labors.

The most important work started by Professor Peirce, and much advanced under his direction, was the actual extension of geodetic work into the interior of the country by continuing the great diagonal arc from the vicinity of Washington to the southward and westward along the Blue Ridge, eventually to reach the Gulf of Mexico near Mobile. He also planned the important work, now in active progress, for measuring the arc of the parallel of thirty-nine degrees, to join the Atlantic and Pacific systems of triangulation, and for determining geographical positions in States having geological or topographical surveys in progress.

He conferred a very important benefit on public interests by so enlarging the scope of the Survey as practically to extend geodetic work into the interior States.

As soon after the war as vessels and officers could be had, he renewed operations for deep-sea soundings and dredgings, and he gave earnest support and aid to all scientific work in any way related to the Survey.

While Superintendent he also took personal charge of the American expedition to Sicily, to observe the eclipse of the sun in December, 1870.

By virtue of his office he was a member of the Transit of Venus Commission, and by his suggestions and active effort he greatly aided that undertaking. Two parties from the Coast Survey were sent out by him,—one to Nagasaki, and the other to Chatham Island, to take part in the work.

The "Quaternion Analysis" of Hamilton seemed to Professor Peirce to promise a very fruitful future. "I wish I was young again," he said, "that I might get such power in using it as only a young man can get." He took great pains to interest his students in it, and in his later years formed a class for its earnest

practical study, with good results. His own thought was turned especially to the logic that underlies all similar systems, and to the limits and the extensions of fundamental processes in mathematics.

At the first session of the National Academy of Sciences, in 1864, he read a paper on the elements of the mathematical theory of quality. Between 1866 and 1870 various papers were read to that Academy, or to this Academy, on "Linear Algebra," "Algebras," "Limitations and Conditions of Associated Linear Algebras," "Quadruple Linear Associative Algebra," etc. These papers were not printed in form as read, but instead in 1870–71 appeared his "Linear Associative Algebra."

His own feeling about this contribution to science is expressed in the salutatory to his friends: "This work has been the pleasantest mathematical effort of my life. In no other have I seemed to myself to have received so full a reward for my mental labor in the novelty and breadth of the results."

An analysis of this treatise was given by Doctor Spottiswoode to the London Mathematical Society, which is characterized by Professor Peirce as "fine, generous and complete." Such an analysis can only come from one who has made a special study of the laws of mathematical thought. To some mathematicians, and other men of science, it may yet be a question, if the time has come for them to say with entire certainty whether this work is to share the fate of Plato's barren speculations about numbers, or to become the solid basis of a wide extension of the laws of our thinking. Those who have thought most on the course which contemporary mathematical science is taking will probably agree that the new ground thus broken can hardly fail to bring forth precious fruit in the future by adding to the powers of mathematics as an instrument.

In any case, the Associative Algebra can never lose its value as an important and most beautiful addition to Ideal Mathematics, and must ever remain a monument to the comprehensive grasp of thought and analytical genius of its author.

Professor Peirce defines mathematics as the science which draws necessary conclusions. Algebra is formal mathematics. Addition is taken to express a mixture, or mere union of elements, independently of any mutual action which might arise if they were to be mixed in reality. From this definition, the commutative character of addition necessarily follows. Multiplication is no further defined than as an operation distributive with reference to addition; but the only algebras treated are those whose multiplication is associative. The subject is further limited to linear algebras, that is, to such as contain only a finite number of lineally independent expres-

sions; so that every quantity considered may be put under the form,

$$ai + bj + ck + \text{etc.}$$

where i, j, k, are peculiar units, limited in number; while a, b, c, are scalars,—a term borrowed from the language of quaternions, but here used in a modified sense to include, not merely the reals, but also the imaginaries, of ordinary algebra. A variety of highly general theorems are given, extending to all linear associative algebras. The author next introduces the conception of a pure algebra, as contradistinguished from one which is virtually equivalent to a combination of several. Methods are developed for finding all such pure algebras of any order. Finally, he obtains the complete series of multiplication tables of these algebras up to the fifth order, together with the most important class of the sixth order. They are in number as follows:

Single Algebras	2
Double "	3
Triple "	5
Quadruple "	18
Quintuple "	70
Sextuple "	65

Professor Peirce never made any extended study of the possible applications of his algebras; he was far from thinking, however, that their utility was dependent upon finding interpretations for them; on the contrary, he showed that certain of them could be advantageously employed, without any interpretation, in the treatment of partial differential equations like that of Laplace.

He read to this Academy in May, 1875, a memoir "On the Uses and Transformation of Linear Algebra," which is, we believe, his only published addition to the principal treatise. He had also made some progress in the investigation of the laws of *non-associative* algebras.

Professor Peirce could not fail to be interested in all questions that concern the equilibrium, the history, and the development of the solar system. At first he was loth to accept the nebular hypothesis in any form. But the results of his studies led him, at last, to defend its main propositions as the true laws of creation.

The rings of Saturn are of prime import in any explanation of planetary development. The discovery by Professor Bond, in 1850, of the dusky ring, and his announcement of reasons for believing that the rings were fluid, multiple, and variable in number, led Professor Peirce to take up the mathematical theory of the rings. He announced, as the result of his analysis, that the rings could not be solid, that a fluid ring could not

have its centre of gravity controlled by its primary, and that it must be supported by the satellites. The principles of the solution were indicated in an article, published in "Gould's Astronomical Journal" in 1851. At different times in the following years some portions of his theoretical treatment of the problem were published. The mathematical possibility of a large number of narrow solid rings was admitted. In the "Memoirs of the National Academy of Sciences" he published, in 1866, the formulas for the potentials and attractions of a ring. This problem has peculiar interest, from the mode of development of the formulas.

The place of comets in the solar system was a subject of his thought even earlier than the rings of Saturn. The discussions and the computation of orbits of various comets in the years 1846–1849, were followed in the latter year by an argument that the comets must have always been parts of the solar system.

In 1859 he applied the theory of solar repulsion of the matter of the comets' tails to the observed form of the tail of Donati's comet, and deduced the strength of the repulsive forces that drove off the nebulous matter. The next year he gave, in a letter to the Academy of Sciences, of Paris, twelve remarkable and suggestive theses on the physical constitution of comets.

In 1861 he made a communication to this Academy, suggesting the meteors as a cause of the acceleration of the moon's mean motion. The paper was not printed, and it does not appear whether he referred to the direct impact of the meteors upon the moon, or to the resistance due to the action of the moon in turning the meteors out of their paths. Probably he included both causes, since each has the effect, to a limited degree, of a resisting medium.

In the last two years of his life he presented to this Academy several communications upon the internal structure of the earth, and the meteoric constitution of the universe. Especially in October, 1879, he gave a series of eight propositions in Cosmical Physics. At an informal scientific meeting at Harvard University he stated five others, which have been since printed in the Appendix to his "Lectures on Ideality in Science." They were given rather as a basis for criticism and discussion than as fully proved. They are founded upon the theory of Mayer, which is advocated by Sir William Thomson, that solar heat, and in part planetary heat, are supplied by the collision of meteors with the sun and planets. Small portions of matter in space cool and become invisible solid meteors. These, by their impact with the sun, produce the violent commotions of the sun's surface. A portion of the earth's heat comes from

the sun, another portion directly from the impact of meteors with the earth's atmosphere. The two portions, he afterwards shows, are equal.

These views are developed more fully in his "Lectures," recently published. The meteors, as Professor Peirce believed, come from the outer portions of the condensing solar nebula. In the course of development an outer shell was left, which furnished the matter to be collected in small masses. The smallest become meteors, the larger comets. Their numbers are enormously great. Arranged according to perihelion distances, the number of comets or meteors coming within a given distance of the sun varies directly as the distance. The heat of Jupiter and Saturn comes from the collisions with those planets. The interior of the earth may be liquid throughout, and the limits set to the lengths of the geologic ages may reasonably be greatly extended.

Any attempt to outline the history of the solar system is sure to lead, in the present state of knowledge, into serious difficulties. Necessarily the problems that arise do not, in many cases, admit of quantitative analysis. The number of unknown elements that appear with every new hypothesis is large; and the more we learn, the larger the number of questions which we cannot answer. It will be but natural if some of the theses of Professor Peirce shall be questioned, and even be proved unsound; but scholars who shall be led into this fascinating field of study will always find in them profound and most suggestive views of creation. Some of these theses will undoubtedly be found to be the true and previously unknown laws of nature.

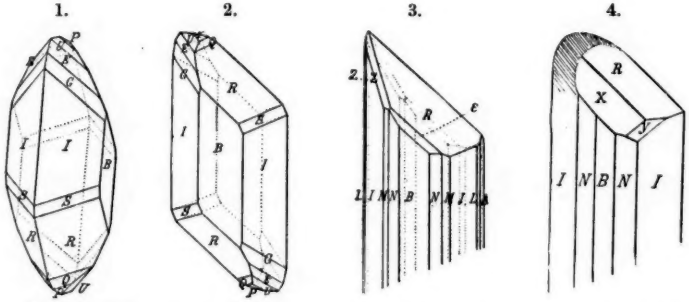
Professor Peirce was always warmly interested in everything that promoted science in this country. He was generous in his estimate of merit, especially of merit in young men. He was one of the founders of the National Academy of Sciences, was an early President of the American Association for the Advancement of Science, was one of the most active members of this Academy, and was a frequent recipient of academic honors. American science mourns in his death the loss it cannot express, but has a higher life for his having lived.

H. A. N.

ART. XXX.—*On the Emerald-green Spodumene from Alexander County, North Carolina;* by EDWARD S. DANA.

THE composition and method of occurrence of the beautiful emerald-green spodumene from Alexander County, North Carolina, was described by Dr. J. Lawrence Smith in a recent number of this Journal;*—the variety was called by him hiddenite after Mr. W. E. Hidden. Dr. Smith's article included a few notes by the writer in regard to the crystalline form of the mineral. The material available for study at that time was scanty and not suited for any accurate determinations of the form. Since then Mr. Hidden has had the kindness to place in my hands a considerable number of crystals, some of them showing the terminations with tolerable distinctness.

The crystals have uniformly a prismatic form, and vary from half an inch to two or three inches in length. They are usually very slender, though sometimes attaining a thickness of one-third to one-half an inch in the direction of the clinodiagonal axis; in the other transverse direction they are much thinner. The crystals show a considerable variety in habit as



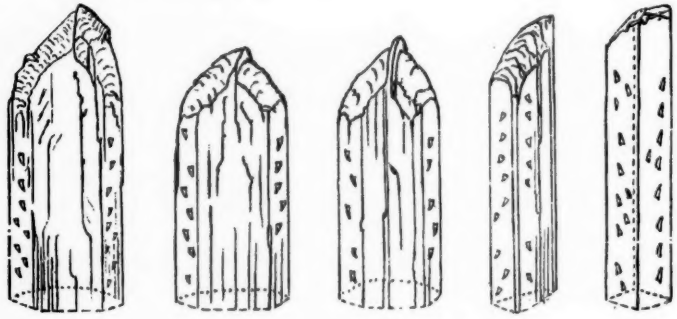
will be inferred from the annexed figures.† Figures 1 and 2 represent the same form but the position of the axes is changed: in fig. 1 the clinodiagonal axis *à* is, as usual, inclined to the front, while in fig. 2 and in the other figures this axis is inclined to the left side, and the orthodiagonal axis *b* projects to the front. The following figures, 5, 6, 7, 8, 9, are from sketches by Mr. Hidden.

The prismatic planes are uniformly striated vertically, and the crystals are not unfrequently rounded by the oscillatory

* Vol. xxi, p. 128, Feb., 1881.

† The engraver, by mistake, has put the lettering of the cuts in capitals instead of small letters.

combination of the occurring planes in this zone; in addition these planes, more especially those of the fundamental prism *I*, are usually pitted with little depressions which will be more particularly mentioned later. The crystals are often flattened



5. 6. 7. 8. 9.

parallel to the clinodiagonal axis but nearly square forms showing only the prism *I* are occasionally observed. The terminal planes, when they may be said to exist at all, for the crystals are usually terminated very irregularly, are always rough, or striated. The only one of the terminal planes which is at all constant in occurrence is the hemi-pyramid *r* ($\bar{3}21$). The planes *g* (681), *e* (241), *u* ($\bar{2}43$), *p* ($\bar{1}11$) form an oblique zone, as shown in figures 1 and 2, and in the majority of the crystals the presence of the same zone is manifest, although no distinct planes are to be determined, the planes rounding uninterruptedly into each other and continuing the front edge (I/I) over the top of the crystals. This feature is shown in fig. 4 and also in figs. 5, 6, 7 which represent twin crystals.

The twin crystals are common, probably more so than the simple crystals. The plane *a* (100) is uniformly the twinning plane and the twinning-axis is normal to it; it is also the composition plane. The twin crystals are usually nearly symmetrical in form (see figs. 5, 6, 7), and the two halves are united in a sharp well-defined line, as proved by an examination with the polariscope. In the case of crystals not terminated, or with terminations too rough to show whether or not they are twins, the composite character is proved by the little depressions on the planes of the prism *I*, since they are inclined in the same direction both in front and behind (figs. 5 to 9).

The observed planes are as follows:—

a	100	i-i	*q*	$\bar{3}32$	$\frac{3}{2}$
b	010	i-$\bar{i}$	*p*	$\bar{1}11$	1
c	001	*O*	*z*	261	-6-$\bar{3}$
l	320	i-$\frac{3}{2}$	*g*	681	-8-$\frac{4}{3}$
I	110	*I*	*e*	241	-4-2
m	120	i-$\bar{2}$	*u*	$\bar{2}43$	$\frac{4}{3}$-2
n	130	i-$\bar{3}$	*ε*	$\bar{2}41$	4-2
s	$\bar{4}41$	4	*x*	$\bar{2}31$	3-$\frac{3}{2}$
r	$\bar{2}21$	2	*y*	$\bar{5}61$	6-$\frac{6}{5}$

Of the above planes *b*, *s*, *q*, *z*, *g*, *e*, *u*, *ε*, *x*, *y*, are new to the species.

Unfortunately, the crystals, while uniformly perfectly transparent, do not in any case allow of even tolerable measurements, so that no more exact values of the fundamental angles could be obtained than those measured by Professor J. D. Dana with the hand goniometer on the large crystals from Norwich, Mass. On this account these angles are accepted as the basis of calculation, viz:

$c \wedge a$ $001 \wedge 100 = 69° 40'$
$I \wedge I$ $110 \wedge 1\bar{1}0 = 93°$
$c \wedge e$ $001 \wedge 021 = 50°$

The corresponding values of the axes are:—

c (vert.) $= 0{\cdot}565$ $\quad b = 0{\cdot}890$ $\quad d = 1{\cdot}000$

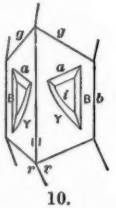
Some of the more important angles (supplement angles) for the occurring planes, calculated from the above axes, are as follows:—

b (010) ∧ *I*	(110)	43° 30′	*b* (010) ∧ *u*	($\bar{2}43$)	40° 16′
" ∧ *l*	(320)	54 55	" ∧ *y*	($\bar{5}61$)	53 27
" ∧ *m*	(120)	25 23	*I* (110) ∧ *g*	(681)	10 18
" ∧ *n*	(130)	17 33	" ∧ *e*	(241)	21 46
" ∧ *g*	(681)	37 3	" ∧ *u*	($\bar{2}43$)	63 8
" ∧ *e*	(241)	36 18	" ∧ *p*	($\bar{1}11$)	75 34
" ∧ *z*	(261)	26 5	*I* ($\bar{1}$10) ∧ *s*	($\bar{4}41$)	17 41
" ∧ *s*	($\bar{4}41$)	41 48	" *r*	($\bar{2}21$)	34 40
" ∧ *r*	($\bar{2}21$)	45 43	" *q*	($\bar{3}32$)	44 22
" ∧ *q*	($\bar{3}32$)	49 57	" *p*	($\bar{1}11$)	59 3
" ∧ *p*	($\bar{1}11$)	58 15	" *y*	($\bar{5}61$)	14 54
" ∧ *x*	($\bar{2}31$)	34 21	" *x*	($\bar{2}31$)	32 14
" ∧ *ε*	($\bar{2}41$)	27 9	" *ε*	($\bar{2}41$)	32 35

As has been stated the measured angles are only rough approximations, they serve however to determine the several planes. As far as needed for this end, in conjunction with the obvious zonal relations, they are as follows:—

I ($\bar{1}$10) ∧ *s*	($\bar{4}41$)	18°	*I* (110) ∧ *g*	(681)	10°
r	($\bar{2}21$)	35	*e*	(241)	22
q	($\bar{3}32$)	45	*u*	($\bar{2}43$)	62
p	($\bar{1}11$)	60	*p*	($\bar{1}11$)	75
y	($\bar{5}61$)	14–15°	*b* (010) ∧ *ε*	($\bar{2}41$)	27
x	($\bar{2}31$)	32	*x*	($\bar{2}31$)	34–34° 30′
			r	($\bar{2}21$)	45–46°

The little depressions observed on the planes in the prismatic zone are an interesting feature of the crystals; those which occur on the planes *I* are the most marked. They appear on the cleavage as well as the natural planes, and often in such numbers as to completely cover the whole surface. Their outline is wedge-shaped and on the front planes (fig. 1) they are inclined upward toward the edge I/I, and similarly downward toward the edge behind in the simple crystals. The form of these depressions is more exactly shown in fig. 10, representing two in symmetrical position and much enlarged. The lower surface is formed by the plane *I*, and the sides by the planes α, β, γ. Of these planes γ is apparently identical with g (681), although, as indicated, it is irregular in its intersection with the prismatic plane being curved; α is a plane in the prismatic zone, with $\alpha \wedge I = 5°$, corresponding to the plane i–$\frac{6}{5}$ or (650) for which the required angle is 5° 13′. The third plane β is in the zone *I*, *g*, *r*, *p*, etc., or that of the unit pyramids. The measured angle of $\beta \wedge I$ is 4°−4° 30′ and this corresponds to the plane $\bar{1}\bar{6}\cdot16\cdot1$ (required $\bar{1}\bar{6}\cdot16\cdot1 \wedge I = 4°18'$). The plane α is sometimes rounded so as to give an oblique intersection with *I*. The depressions on the plane *b* are also common though less conspicuous than those just named. They are rhomboidal in shape and the outlines are respectively parallel to the prismatic edge, and to the edge b/r.



10.

An examination of a section in the polariscope showed that the bisectrices lie in the plane of symmetry, and that the acute bisectrix (positive) is inclined to the front (fig. 1) edge of I/I at an angle of 26°. These determinations agree exactly with the results given by DesCloizeaux (Mineralogy, p. 351, 1862). A suitable section for measuring the optic axes has not as yet been obtained, one which promised to be satisfactory went to pieces in the hands of the lapidary owing to the highly perfect cleavage parallel to the prism *I*.

It is a matter of some mineralogical interest to note that this variety of spodumene has already found a place among the highly valued gems. The color of the finest crystals is a deep emerald green, and when suitably cut the stones are very beautiful; owing to the dichroism there is a peculiar fire to them which is wanting in the true emerald. The largest stone cut thus far weighs very nearly $2\frac{1}{2}$ carats. Explorations are now being carried on at the locality under the direction of Mr. Hidden.

ART. XXXI.—*The Objects and Interpretation of Soil Analyses;* by E. W. HILGARD, Professor of Agriculture at the University of California.

THE claim of soil analysis to practical utility has always been rested on the general supposition that, "*other things being equal,—productiveness is, or should be, sensibly proportional to the amount of available plant food within reach of the roots during the period of the plants' development;*" *provided,* of course, that such supply does not exceed the maximum of that which the plant can utilize, when the surplus simply remains inert.

The above statement has been, either tacitly or expressly, admitted as a maxim by those who have attempted to interpret soil analyses at all; it being thoroughly in accordance with the accumulated experience of agriculturists, and with their cry for "enough manure" that has been so potent a factor in the development of agricultural science, and of rational agriculture itself. Its acceptance is implied in the search for the solvent that shall represent correctly the action of the plant itself on the soil ingredients; and I shall take it for granted in this discussion, while strongly emphasizing the proviso, especially with reference to physical conditions.

Methods of Soil investigation.—It is universally admitted that the *ultimate* analysis of soils affords little or no clew to their agricultural value; such agents as fluohydric acid and alkaline carbonates go by far deeper than the solvents, naturally acting in soils bearing vegetation, will go within the limits of time in which we are interested.

Many attempts have been made to find solvents whose action on soils would so nearly represent the agents subservient to the needs of vegetation, that conclusions as to the present agricultural value of a given soil could be deduced therefrom. It is needless to recite the long list of such solvents, suggested since soil analysis attracted attention. From fluohydric acid to water charged with carbonic acid, the acid solvents have all signally failed to secure even an approximation to the result desired, viz: a consistent agreement between the quantitative determinations, or the percentages of plant food, found in the several soils, and the actual experience of those who cultivate them.

It has been attempted by the German experiment stations, under Wolff's initiative, to gain an approximation to the relative availability of parts of the soils' store of plant food, by consecutive extractions with acid solvents of different strength, beginning with distilled water and ending with boiling oil of

vitriol or fluohydric acid. I cannot wonder that this laborious process, with solvents arbitrarily chosen, and without any known relation to the solvent action exerted by roots, should have found so little acceptance, and has on the contrary perhaps rather served to confirm the common impression of the uselessness of soil analysis; especially when contrasted with such a huge amount of work, ending after all in mere guesses. I have vainly sought, in the recorded results of such investigations, for any such ray of light on the functions of the several soil ingredients, as would even remotely justify the labor involved.

Causes of failure.—I think there have been two chief factors that have contributed to bringing soil analysis into disrepute in Europe; one is, the fact that virgin soils are there practically non-existent, nearly all the soils analyzed having been at some time subjected to cultivation and concurrently, to the use of manures, thus veiling their original characteristics, and rendering extremely difficult, to say the least, the taking of any sample of soil that shall correctly represent the whole of a large field or district. The second is, the absence of systematic investigation of the subject, since the time of the introduction of the most essential improvements in the determination of some of the chiefly important mineral soil ingredients.

Advantages and need of Soil investigation in the United States.—It is our special and exceptional privilege, that we are still able to secure specimens of the soils of by far the greater portion of the United States, that even the plow has never yet touched, and where manure, outside of the flower and vegetable garden, is an unknown quantity. We can find on these soils their original vegetation, which is so largely used by the settler as a means of diagnosing the actual productiveness of the land he proposes to clear, and of prognosing its durability. The value of this method is so emphatically recognized as to have given rise to the remark, by a distinguished member of this body, that he "would rather trust an old farmer to tell him about the value of a soil, than the best chemist alive."

Now, we may perhaps agree with Professor Johnson in this matter, so long as we find the old farmer on his native heath, and so long as he is exceptionally intelligent. But all farmers are not old; and it is particularly the young ones that stand in need of advice, when they "go west." Moreover, old farmers will frequently disagree widely in their estimate of the qualities and value of a soil; and then who shall decide? And who shall tell the hundreds of thousands of settlers and emigrants annually occupying new lands of whose quality, at present, no one knows anything, what they may reasonably expect of their soil, apart from the bare assertions of inter-

ested parties? How shall they know, in the absence of the old farmer, whether in establishing their homestead in a given locality, they do so for weal or woe, and in which direction they are most likely to secure the highest returns and the longest duration of fertility; and in which direction the first effects of soil-exhaustion will make themselves felt, and how they can best be countervailed?

If the agricultural chemist can do nothing to help the farmer in these important questions, his practical utility will be limited indeed. And how is he ever to be able to render these services, if he continues to ignore the chemical examination of the soils, upon the strength of the "non possumus" pronounced by some high priests?

I cannot consider the *testimonium paupertatis*, implied in the remark above referred to, as well founded. If the old farmer can train his judgment in this matter so as to make shrewd guesses, the agricultural chemist ought to be able to do a great deal better; for he should know all that the farmer does, and a great deal more besides; and, in addition, he should bring to bear on the whole subject a well-trained mind, accustomed to accurate observation and logical reasoning; unlike the old farmer who "knows" that "wheat turns into cheat" in unfavorable seasons.

The chemist who does no more than to give the farmer a column of figures summing up to one hundred or nearly so, opposite another column of unintelligible names, acts simply as an analytical machine; and even to the best of such machines, Professor Johnson's remark will most truly apply. Their enunciations are as enigmatical as those of the Delphic oracle, and as little useful to the farmer as the most accurate analytical formula for calculating the motion and friction of water in pipes would be to the hydraulic miner who stands at the nozzle of the "monitor." Both the miner and the farmer might be greatly benefited by the information conveyed, if they could only understand it.

Since, then, the figures of a soil analysis, no matter how made, do not interpret themselves, by what rule or rules shall we be governed in interpreting them for practical purposes?

Of the older attempts in this direction, it is scarcely necessary to speak. What remains of them at this time, may be briefly summed up in the statement, that it is usual to judge a soil by its absolute percentages of plant-food on the one hand, and by such scanty information as we can elicit regarding their availability, on the other. As to what constitutes "much" or "little" or "a deficiency" of any one ingredient, doctors differ as widely as in respect to the classification of soils. It has been usual to take a notoriously very rich soil as a type, and com-

pare others therewith; but even a cursory comparison shows that, in many cases, soils showing percentages of plant-food very much inferior to those of the type are nevertheless in practice found quite as productive; and that even in cases where precisely the same solvents had been used in their extraction. These facts are too well known to require exemplification; and they led to the exclusive adoption, in the study of the part played by the several soil ingredients, of the methods of culture on artificial soils or in solutions of known composition.

The radical fault of these methods is that they necessarily deal with plants placed under artificial conditions, and with mediums of nutrition whose comparison with natural soils is at best a lame one; necessarily so, until we shall know much more than we do of the intimate condition and functions of the soil as a whole, and of its ingredients, both severally and jointly. And while the artificial cultures have given us some exceedingly valuable information as to the relative importance of certain soil ingredients, it is still held by some of the highest agricultural authorities, that the only way to obtain practically useful data as to the best method of soil improvement in any particular case, is to *go and try*—first on the small, and then on the large scale; and when a particular kind of manure finally fails of effect, to go and try again; and so on.

Are we then really reduced to such empiricism as this—are the permutations and combinations of nitrogenous, phosphate and potash manures, all that agricultural chemistry can do for the western farmer, when his "inexhaustible" soil begins to be "tired?"

System of investigation adopted.—Unwilling to abide by this lame solution of the problem, I have endeavored to solve it, or at least to approach its solution, from a somewhat different side, as suggested by the opportunities offered in the agricultural surveys of the newer States. Taking for granted the soundness of the old farmer's judgment of the productiveness of a soil from its natural vegetation, I have sought to determine, by close chemical and physical examination of the soils in their natural condition, the causes that determine this natural selection on the part of certain species of trees and herbaceous plants; while at the same time observing closely the behavior of such soils under cultivation, their special adaptations, etc. It goes without saying that this can be done most successfully where, as in the Western and Southern States, virgin soils are still obtainable, where manure is unknown, and where the simple history of each field can easily be gathered from the lips of the settler who first broke the sod.

It is evident that when used in this connection, and made uniformly and systematically, with a definite problem in view,

each soil analysis becomes an equation of condition; and that by the proper treatment of a large number of such, by a logical process of elimination, the problem of the function and value of each soil-ingredient or soil-condition can be approached with a better prospect of a solution in accordance with *natural* conditions, than can be expected from cultures upon artificial soils, or in solutions.

My first trials of the efficacy of this method of investigation were made upon the soils of the State of Mississippi, which, fortunately, present extreme variations in character in almost every direction, and upon every key, so to speak, of the soil scale. But for this fact, I might, like many before me, have abandoned in despair, the hope of attaining any definite results. Some of the conclusions reached in this work have been given in previous papers (this Journal, Dec., 1872, and others). Since then, the material has been considerably increased, and quite lately, the investigations made under the auspices of the census office, upon the soils of the cotton States, have greatly added thereto, and given a wider scope to the comparisons. The detailed record and discussion of the facts so gathered will form part of the Census report on cotton culture, and in any case would be far too voluminous for presentation here. I must therefore confine myself to indicating, in general, some of the main points involved.

The taking of representative soil specimens is, of course, a matter of first importance, and sometimes of no little difficulty. All those analyzed under my direction have been taken in accordance with printed directions, with care in the selection of proper localities, the discrimination between soil and subsoil, a record of depth, natural vegetation, behavior in cultivation, etc. As heretofore stated, I find that with such care, it is perfectly practicable to obtain samples representing, typically, soil areas of many thousands of square miles; especially so when the subsoils are taken as the more reliable indices.

Method of Analysis.—In the selection of the *solvent for making the soil-extract* to be analyzed, I have been guided by the consideration, that minerals not sensibly attacked by several days' hot digestion with strong hydrochloric acid, are not likely to furnish anything of importance to *agriculture*, within a generation or two. If this assumption seems arbitrary, it at least commends itself to common sense. The heavy draught made upon the soil by the removal of crops cannot be sensibly effected by the minute additions made to the available plant food by the atmospheric or root action on such refractory minerals.

Regarding the *strength of acid* to be used, and the *time* necessary to secure the solution of the important substances, I have

caused investigations to be made by Dr. R. H. Loughridge (this Journal, Jan., 1874, p. 20), on a subsoil selected for its representative position and derivation—a drift soil covering, probably, some 15,000 square miles in the uplands of Western Tennessee and Mississippi, and perhaps as fully "generalized" in its origin as can be obtained. The result of this investigation was that hydrochloric acid of about the specific gravity of 1·115 seems to exert the maximum effect, and that the extraction is practically complete after a water-bath digestion of five days. These conditions of digestion have been substantially maintained in all the investigations made under my direction. An excess of time of digestion results simply in higher percentages of alumina and soluble silica, or what is equivalent, in a farther decomposition of kaolinite particles.

The *methods of analysis* used by me are substantially those given in the first Kentucky Report, volume I, by Dr. Robert Peter, with such changes as the progress of analytical chemistry suggested. All the reagents have been especially prepared, or purified, in the laboratory itself; porcelain beakers only have been used in the digestions; and generally every possible precaution has been taken to insure correctness in the determination of the minute percentages of the important ingredients. Numerous repetitions have, in most cases, confirmed the correctness of the work.

Of other determinations, the one preceding all analytical operations has been the determination of the "moisture-coefficient" of the "fine-earth," by exposing a very thin layer of the same to a *fully* saturated atmosphere for at least twelve hours, at a sensibly constant temperature. As previously stated, I have in these determinations come to results differing materially from those obtained by Knop, Schübler, and others; probably because of the more complete fulfillment of the conditions of full saturation of air as well as soil. I find that for most soils, the absorption-coefficient is practically constant at temperatures between +7° and +25° C.; and contrary to the conclusions reached by Adolph Mayer.

I find that this coefficient exerts an exceedingly obvious and important influence upon the actual productiveness of soils. An investigation reaching beyond the temperature-limits mentioned, and also embracing the use of a partially saturated atmosphere, has just been made in my laboratory and will shortly be published.

A determination of the total "*volatile matter*" of the soil, that is, its organic matter and combined water, by ignition, is made on the portion of soil used for the determination of *phosphoric acid* by means of molybdic acid. While this determination is necessary to the "summing up" of the analytical state-

ment, it is not in itself very instructive, as it leaves the relative amounts of the two substances altogether indefinite. A determination of the organic matter by combustion, or by extraction with potash lye, is also unsatisfactory, because of the impossibility of excluding from these determinations, a large amount of comminuted, but altogether crude and unhumified, vegetable matter; which becomes very obvious under the microscope, or in the process of silt-analysis. I have therefore adopted for the determination of active humus, the admirable method of Grandeau, by the aid of which at least a uniform *minimum* determination becomes possible.

I have not devised any method for the direct determination of the *water of hydration*, although there are cases in which it would be very desirable to have this item, for the determination of the condition of the alumina and ferric oxide.

I have in a few cases determined the amount of *silica soluble* in boiling solution of sodic carbonate in the *crude* soil. But this determination is often beset with almost insuperable mechanical difficulties, from the diffusion of the clay in the alkaline liquid. It does not appear to promise results of sufficient importance to justify such labor; the more, as by the method of Grandeau, the actual available amount of silica can probably be better determined. But I have found the determination of the *silica soluble in the alkaline carbonates, in the "insoluble residue" of the acid extraction*, of very great interest. Evidently, in so far as it is derived from the decomposition of clay, "kaolinite," it should stand in a definite ratio to the alumina dissolved by acid, and this is often very strikingly the case. But sometimes the soluble silica is so entirely out of proportion to (below) the amount required to form kaolinite with the dissolved alumina, as to prove that the latter is present in a different condition; the only possible one in that case being that of hydrate. This fact, doubtless, accounts for a great deal of the otherwise incomprehensible variations in the properties of soils and certain clays, which I shall hereafter discuss. I should also mention in this connection that I have strong evidence of the presence of still another hydrous silicate, related to saponite, in some of the tertiary "prairie soils" of the Southern States; the peculiarities of which, when under cultivation, have seemed unintelligible.

I have not yet been able to extend the method of Grandeau for humus extractions over a sufficient number of widely different soils of well known characteristics, to consider the claim of its furnishing a definite measure of the available plant-food in the soil, as definitely established. But thus far I have found nothing to contradict this probable assumption, and much tending to its confirmation; and I hope to be able to continue the

investigation of its relation to the productiveness of soils, to a definite conclusion. There can be no reasonable doubt that what *is* extracted by Grandeau's ammonia water is at the command of the solvents employed by plants; the only question is, to what extent plants can readily go beyond. This of course requires extended culture experiments, on a great variety of soils.

The determination of the *phosphoric acid* and *silica* in the residues from the ignition of Grandeau's extracts have already furnished most important data concerning the cause of the productiveness of some soils having comparatively a low percentage of phosphates.

As regards the determinations of *nitrogen* and its compounds in the virgin soils thus far analyzed, I have omitted them in part from want of time and proper appliances for these delicate determinations, and partly from a doubt of their usefulness. The constant variation and inter-convertibility of nitrates and ammonia-compounds renders their determination at any given time, of interest for that time only; and as the nitrogen percentage of the mould of natural soils adapted to agriculture is not likely to vary much, the humus-percentage may probably be taken as roughly proportional to the total nitrogen of the soil. A full investigation of this subject is, of course, also called for. On the other hand, I find that the fulfillment of the conditions of nitrification in the soil, is in all cases a condition of its thriftiness.

Interpretation of the analytical results.—Having obtained, as above outlined, the percentage composition of a soil, how are we to interpret these percentages to the farmer? what are "high" and "low" percentages of each ingredient important to the plant, whether as food or through its physical properties?

The first question arising in this connection, is naturally, whether all soils, having what experience proves to be high percentages of plant-food when analyzed by the processes above given, show a high degree of productiveness?

So far as my experience goes, this question can, for virgin soils, be unqualifiedly answered in the affirmative; *provided* only, that improper physical conditions do not interfere with the welfare of the plant.

But it does not therefore follow, as was at first supposed, that the converse is true, and that low percentages necessarily indicate low production. This will be apparent from a simple consideration.

Suppose that we have a heavy alluvial soil of high percentages, and producing a maximum crop in favorable seasons. We may dilute this soil with its own weight, or even more, of coarse sand, thereby reducing the percentages to one-half, or

less; and yet it will not only not produce a smaller crop, but it is more likely to produce the maximum crop every year, on account of improved physical conditions. If we compare the root system of the plants grown in the original, and in the diluted soil, we will find the roots in the latter more fully diffused, longer, and better developed; not confined to the crevices of a hard clay, permeating the entire mass, and evidently having fully as extensive a surface-contact with the fertile soil particles, as was the case in the undiluted soil.

How far may this dilution be carried without detriment?—The answer to this question must largely be experimental and must vary with different plants; which is precisely what the farmers' experience has shown, long since. A plant capable of developing a very large root-surface, can obviously make up by greater spread, for a far greater dilution than one whose root surface is in any case but small. The former flourishes even on "poor, sandy" soils, while the latter succeeds, and is naturally found on "rich, heavy" ones only; although the absolute amount of plant-food taken from the soil may be the same in either case.

Now the conditions here supposed are frequently fulfilled in nature, and more especially so in alluvial soils. Among many striking examples that might be given, are the analyses of two soils about equally esteemed for the production of cotton, both equally durable, so far as experience has gone, and yet differing so in their percentages of mineral plant-food, to the extent of from three to five times.

In cases like these, which are not at all infrequent, the mere percentage of plant-food in the soil showing the low figures, would lead to a most erroneous estimate of its agricultural value. But when, in addition to these, we know the fact that in the one, the food-roots can exercise their functions to the depth of three or four feet, while in the richer soil with ordinary cultivation, they will rarely reach to a greater depth than twelve or fifteen inches, the equal productiveness becomes quite intelligible.

It is obvious, then, that without a knowledge of the respective depths and penetrability of two soils, a comparison of their plant-food percentages will be futile. Nor is it feasible to agree upon a certain depth to which all soils analyzed should be taken. The surface soil with its processes of humification, nitrification, oxidation, carbonic acid solution, etc., in full progress, must always be distinguished from the subsoil in which these processes are but feebly developed, and where the store of plant-food—in which it is generally richer than the surface soil—is comparatively inert. Hence the obvious importance of specimens correctly taken, and the necessity of intelligent and accurate observations on the spot.

I have attempted to make allowance for the cases of dilution, as above noticed, by combining the results of the mechanical with those of chemical analysis. In the investigation made by Dr. Loughridge, of the several sediments obtained in the mechanical analysis of the typical soil above referred to—see this Journal, Jan. 1874—it appeared that plant-food practically ceased to be extracted from sediments exceeding 5^{mm} hydraulic value; and in re-calculating the percentages of soils *of the same general derivation*, after throwing out the coarser sediments, we often find very striking approximations to identity of percentage composition, as well as of proportionately *inter se*. It is obvious, however, that this cannot be generally true; since inert clay or impalpable silt must often come in as diluents. Nevertheless, I consider the mechanical analysis of soils (carried out by the method heretofore described by me, and *not* in accordance with that of the German experiment stations), as an almost indispensable aid in judging fully of the agricultural peculiarities of soils, especially when these cannot be personally examined in the field.

The concentration of the available portion of the plant-food of soils in their finest portions is almost a maxim already, scarcely needing the corroboration afforded by the investigation of Dr. Loughridge above quoted. A "strong" soil is invariably one containing within reach of the plant a large amount of impalpable matter, although the reverse is by no means generally true. Striking corroborations of this maxim are afforded by the steady increase of certain plant-food percentages in the deposits of streams as we descend, and the proverbial richness of "delta" soils is exactly in point.

"High" and "low" percentages and their interpretation.—I will now state, as concisely as possible, some of the main points I consider as substantially proven by the comparisons of soil analyses made upon the uniform plan outlined above. The detailed record upon which these conclusions rest, would render this paper far too long, but will be given in the Census report upon cotton culture.

1. *Other things being equal, the thriftiness* (i. e., present productiveness) *of a soil is measurably dependent upon the presence of a certain minimum percentage of lime.*

The evidence I can present in support of this maxim is overwhelming. It is obvious to the eye in thousands of cases, when the significance of the occurrence of certain trees, esteemed by the "old farmer" as certain signs of a productive soil, is once understood. Almost all the trees he habitually selects as a guide to a good "location," are such as frequent *calcareous* soils, using the term, however, in a somewhat different meaning from that usually given it. That is, I find that in order to manifest itself

unequivocally in the tree-growth, the lime-percentage should not fall below 0·100 in the lightest sandy soils; in clay loams not below a fourth of one per cent, 0·250; and in heavy clay soils, not below 0·500, and may advantageously rise to one and even two per cent. Beyond the latter figure, it seems in no case to act more favorably than a less amount, unless it be mechanically.

The effect produced by the presence of such, or greater percentages of lime in the soils seems to be a kind of "aufschliessung," an energizing or rendering active of that which otherwise would remain inactive. This becomes evident at once in the smaller insoluble residues from the acid treatment, yielded by such soils; there being then oftentimes a complete dissolution of the alumina, a large part of which ordinarily remains behind in the shape of clay (kaolinite-particles). It would seem that as regards the silicates, the carbonate of lime in soils performs in a measure, the same functions as the caustic lime in Lawrence Smith's method of silicate "aufschliessung." We have an indication of the same action in the case of marls, whose small percentages of potash and phosphates act so energetically, and in which we so often find the potash in the highly available form of glauconite grains; also in the displacement of potash from zeolitic compounds, by lime or lime salts.

From the evidence before me, I should specify as follows, the advantages resulting from the presence of an adequate supply of lime in soils:

a. A more rapid transformation of vegetable matter into *active* humus which manifests itself by a dark, or deep black tint of the soil.

b. The retention of such humus, against the oxidizing influences of hot climates; witness the high humus-percentages of such soils, as against all others, in the Southern States.

c. Whether through the medium of this humus, or in a more direct manner, it renders adequate for profitable culture percentages of phosphoric acid and potash so small that, in the case of deficiency or absence of lime, the soil is practically sterile.

d. It tends to secure the proper maintenance of the conditions of nitrification, whereby the inert nitrogen of the soil is rendered available.

e. It exerts a most important physical action on the flocculation, and therefore on the tillability of the soil, as heretofore shown by Schlœsing and by myself.

I may add that in the great majority of soils (excepting those that are extremely sandy) the lime-percentage is greater in the subsoil than in the surface soil. This is, doubtless, the result of the easy solubility of calcic carbonate in the soil water, which carries it downward and thus tends to deplete the sur-

face soil. This fact is strikingly shown in the results of Loughridge's investigation on the composition of the several sediments. (This Journal, January, 1874, p. 19).

The efficacy of lime in preventing "running-to-weed" in fresh soils, and in favoring the production of fruit, is conspicuously shown in a number of cases.

This controlling influence of lime renders its determination, alone, a matter of no small interest; since its deficiency can very generally be cheaply remedied, avoiding the use of more costly fertilizers.

I have been unable to trace any connection of *magnesia* with any of the important qualities of soils. Its percentage is usually larger than that of lime, frequently about double.

2. The *phosphoric acid* percentage is that which, in connection with that of lime, seems to govern most commonly the productiveness of our virgin soils. In any of these, less than five hundredths (0·05) must be regarded as a serious deficiency. In sandy loam soils, one-tenth (0·100), when accompanied by a fair supply of lime, secures fair productiveness for eight to fifteen years; with a deficiency of lime, twice that percentage will only serve for a similar time. The maximum percentage thus far found in an upland soil by my method of analysis, is about a quarter of one per cent (0·250), in the splendid table-land soils of West Tennessee and Mississippi. In the best bottom ("buckshot") soil of the Mississippi, three-tenths (0·30). In that of a black prairie of Texas, 0·46 per cent, this being the highest figure that has come under my observation.

How the lime compounds contained in the soil act in rendering the phosphates more available, I do not pretend to discuss at present. A number (far too limited as yet) of determinations made according to Grandeau's method, appear to confirm the inference that calcareous soils yield to this treatment a larger relative percentage of available phosphoric acid, than those deficient in lime.

3. The *potash-percentages* of soils seem, in a large number of cases, to vary with that of "clay;" that is, in clay soils they are usually high, in sandy soils low; and since subsoils are in all ordinary cases more clayey than surface soils, their potash-percentage is almost invariably higher also. 1·3 per cent K_2O is the highest percentage obtained by my method of extraction, and that from the same soil that afforded the second highest phosphate percentage also, the "buckshot" of the Mississippi bottom, noted for its high and uniform production of cotton. As the same soil contains 1·4 per cent of lime, and is jet black with humus, it may well serve as the type of a fertile soil.

The potash-percentage of heavy clay upland soil and clay loams ranges from about 0·8 to 0·5 per cent, lighter loams from 0·45 to 0·30, sandy loams below 0·3, and sandy soils of great

depth may fall below 0·100 consistently with good productiveness and durability; the former depending upon the amounts of lime and phosphoric acid with which it is associated. Virgin soils falling below 0·060 in their potash-percentage seem, in all cases that have come under my observation, to be deficient in available potash, its application to such soils being followed by an immediate great increase of production.

Since but few soils fall below this minimum, my general inference has been that potash manures are not among the first to be sought for after the soils have become "tired" by exhaustive culture. The universal preference given to phosphatic and nitrogenous fertilizers in the west and south, is in accord with this inference. In the older portions of the United States, "kainite" is becoming more important, while in the alkali lands of California, soluble potash salts often impregnate the soil water.

4. In all soils not specially impregnated with sea or other salts, the amount of *soda* extracted by the acid is considerably *below* that of potash in the same soil, varying mostly from one-eighth to one-third of the percentage of the latter. When much more is found in such soils, a repetition of the determination will usually show that the separation from magnesia was imperfectly made. I can trace no connection between the soda percentage and any important property of the soil, any more than in the case of *magnesia* and *manganese*, albeit none of these is ever absent from ordinary soils.

5. *Sulphuric acid* is found in very small quantities only, even in highly fertile soils. From two to four hundredths of one per cent (0·02 to 0·04), seems to be an adequate supply, but it frequently rises to one-tenth (0·1) per cent, rarely higher.

6. *Chlorine* I have as a rule left undetermined, on account of its constant variability and universal presence in waters, and acknowledged slight importance to useful vegetation.

7. *Iron*, in the shape of ferric hydrate finely diffused, appears to be an important soil ingredient on account of its physical, and partly also its chemical properties. The universal preference given to "red lands" by farmers, is sufficiently indicative of the results of experience in this respect, and I have taken pains to investigate its causes. The high absorptive power of ferric hydrate for gases is probably first among the benefits it confers. Red soils resist drought better than similar soils lacking the ferric hydrate. And here I must again call attention to the strange fallacy in Adolph Mayer's experiments on the wilting of plants in drying soils, from which he deduces as probable, the maxim that the hygroscopic coefficient of soils is a matter of indifference to plants. His plants *in pots* were not under the conditions in which field crops are when called upon to resist drought, whether from drying winds, or hot sun.

Here the continuous rise of moisture from the subsoil tends to keep up the supply to the water roots, while at the same time nutrition, as is well-known, continues almost unabated in air-dry soils, so long as there is no injurious rise of temperature in consequence of that dryness. But that is precisely the point where a high moisture-coefficient comes into play, by preventing, in consequence of evaporation, a rise of temperature that, under similar circumstances would prove fatal to the surface roots of the crop in soils of low absorption power. In fact, Mayer's conclusion is at variance with the ordinary experience of centuries, repeated every day in the droughty regions of the South and of the Pacific coast. It takes more than flower-pot experiments to invalidate the universal designation of soils of low hygroscopic power, as "droughty."

The moisture-coefficient depends in ordinary soils, upon one or more of four substances, viz: (in the order of their efficacy), humus, ferric hydrate, clay and lime. It varies in cultivatable soils from about 1·5 to 23 per cent at 15° C., and in a saturated atmosphere. A pure clay rarely exceeds 12 per cent; ferruginous clays show from 15 to 21; some calcareous clay soils rise nearly as high, while peaty soils rise to 23 per cent and even more, but the efficacy of the ferric hydrate depends essentially upon a state of fine division. When merely incrusting the sand-grains, or aggregated into bog-ore grains, it exerts little or no influence, although the analysis may show a high percentage. Sometimes soils highly colored show but a small iron percentage, while yet, on account of very fine diffusion, the advantages referred to are realized.

From 1·5 to 4·0 are ordinary percentages of ferric oxide, occurring even in soils but little tinted. Ordinary ferruginous loams vary from 3·5 to 7·0, highly colored "red lands" have from 7 to 12 per cent, and occasionally upward to 20 and more.

Of course, a large amount of ferric hydrate facilitates the tillage of heavy clay soils, and its color tends to the absorption of heat. But I incline strongly to the belief that the benefits of its presence are not confined to physical action. From the fact that highly ferruginous soils rarely have a high percentage of humus, it appears that the former acts as a carrier of oxygen to the latter, and thus probably favors, especially, nitrification.

On the other hand, such soils are the first liable to damage from imperfect drainage, overflows, etc. The reduction of the ferric hydrate to ferrous salts, most commonly in the subsoil, manifests itself promptly by the "blighting" of the crop. But under natural conditions this can rarely occur, because a frequent recurrence of conditions favoring reduction will inevitably result in a gradual bleaching of the soil, and an accumulation of its iron in the subsoil in the form of bog-ore or "black pebble."

In bringing forward this hasty summary of the conclusions either definitely justified or foreshadowed by my investigations on the subject of soil composition, I do not, of course, look for their acceptance until the record and proofs shall be forthcoming, as they soon will, in another publication. My present object is to call attention once more to the fundamental and practical importance of the subject of soil examination by all available means, and to protest against the contemptuous, unreasoning putting aside of the whole matter of soil analysis, that has become current in works on agricultural chemistry for some time past. If the chemists of Europe are content to declare themselves incompetent to accomplish anything more than mere guesses by the analysis of their long cultivated and manured soils; if the same should even be held as regards the well-worn soils of New England, the objection cannot be sustained as against the virgin soils of our newer States and Territories, or even as against *any* soils that have not been manured as yet, these two classes constituting, probably, four-fifths of all the cultivatable lands of the United States. These soils have been subjected only to natural, or to definitely ascertainable artificial influences. They are sensibly uniform over very large areas, or at least, vary uniformly; they still possess, in part at least, their original tree or other growth, as produced by natural selection. Is it reasonable that in the presence of such opportunities American chemists should also declare themselves incompetent, without even trying to accomplish that which both in a theoretical and in a practical point of view, cannot be held otherwise than as of prime importance?

No one can be more sensible than I myself, of the small amount of progress made in the matter of *à priori* recognition of the agricultural character and value, present and ultimate, of soils, in the twenty-five years during which I have more or less pursued the study of the subject. It would doubtless have been otherwise had any one besides myself worked in this field of research with similar objects and methods. By the early death of Dr. David Dale Owen, I was deprived of the one through whose initiative and encouragement I first entered upon and persevered in this field, through the discouragement freely bestowed upon me by my fellow-chemists; and thus the excellent work done by Dr. Robert Peter, Dr. Owen's chemical assistant in the survey of Kentucky and Arkansas, in the analysis of the soils of those States, has so far remained without an interpreter. If the facts, suggestions and views here presented should be successful in attracting to this field of research some of the attention now so lavishly bestowed on the investigation of recondite organic compounds, the object of this paper will have been attained.

Art. XXXII.—*Mineralogical Notes;* by B. Silliman.

1. Vanadinite and other Vanadates, Wulfenite, Crocoite, Vauquelinite, etc., from Arizona.

I here record the discovery of two important and very interesting mineral localities, or districts, in the Territory of Arizona, from one of which I have obtained vanadinite of remarkable beauty of color and perfection of crystalline form, associated with almost equally beautiful wulfenite of an orange-red color; and from the other, four, perhaps more than four species containing vanadium. The last named district has also furnished crocoite and vauquelinite never found before, I believe, in North America.

I am greatly indebted to my faithful and intelligent correspondent, Mr. George A. Treadwell, of Vulture, Arizona, for sending me, for some years past, a great number of minerals and ores collected by him in that Territory, among which are those now to be described. I mention also, with pleasure, the aid afforded me by Mr. Edward Farley, of Wickenburg, owner of several interesting veins, and Dr. Jones, of Phœnix. Mr. F. F. Thomas, lately in charge of Silverlead Furnaces, near Silent, in Arizona, and Mr. John McDougal, Superintendent of mines, have also contributed important data in extending our knowledge of that interesting Territory.

Vanadinite.—This hitherto rare species promises now to be comparatively abundant. In the so-called "Silver District," in Yuma County, Arizona, about fifty miles north of Fort Yuma, is a large area traversed by veins of quartz carrying argentiferous galena, with salts of lead, but no gold, and rather extensively explored. The lead salts which I have seen from this region are wulfenite, of remarkable beauty, vanadinite, and massive anglesite with galenite. Vanadinite occurs in three mines, near together, the "Hamburg," the "Princess" and the "Red Cloud." The crystals of vanadinite are extremely beautiful, alike for brilliancy of color, luster and perfection of form. Only a single vanadate appears to occur in the Silver District; but there may be an exception to this remark, since a greenish yellow incrustation on one specimen may turn out to be volborthite or one of the other amorphous vanadium minerals. All the veins of this district occur, as I am informed by Mr. Thomas, between a foot-wall of granite and a hanging-wall of porphyry, specimens of which rocks I have in hand. The foot-wall of granite is somewhat irregular, but the porphyritic hanging-wall is well defined. I have not yet made sections of the latter rock; it closely resembles the augite trachytes of Nevada and elsewhere,

the usual associates of silver ores the world over. All these lodes abound in calcareous matter, but there are no limestone beds in the vicinity; and in the absence of any organic remains, we are ignorant of the probable geological horizon.

"The Hamburg" mine has furnished the most numerous and, on the whole, the best specimens of vanadinite. The crystals vary in color from deep orange-red—deeper than potassium bichromate, but not ruby—through lighter shades of orange-red to reddish-yellow and brown. They are always highly lustrous. The size is small, the length being not over two millimeters and usually less than one; and the diameter about half the length to equal dimensions. The hexagonal prisms are modified usually by one, sometimes by two planes on each terminal edge, and occasionally the angles are replaced. These crystals are implanted singly and in crusts on a dark chocolate-colored siliceous gangue, with occasional obscure crystals of cerussite, and rarely a dark-colored cleavable lime-rock (impure calcite).

The "Red Cloud" mine furnishes vanadinite of a rich orange-red or flame-color, associated with beautiful orange-red wulfenite. At the depth of 280 feet, measured on the slope of the vein, wulfenite takes the place of vanadinite almost to its exclusion. The crystals of vanadinite at this mine are smaller and grouped in more confused masses than at the Hamburg mine.

At "the Princess" mine, the vanadinite occurs in slender crystals of a brilliant red color almost identical with that of crocoite, implanted upon white calcite. The habit of the species is unlike either of those before mentioned; the crystals are at least four diameters long and are very slightly modified. They are not over half a millimeter in diameter, but are very perfect in form, luster and color. They have, naturally enough, been mistaken for chromate of lead.

The genesis of the vanadates of these mines is obscure. A single small specimen only of the galena has reached me. It forms the nucleus of a surrounding mass of amorphous anglesite, upon the outer surface of which appear obscure crusts of vanadinite. Analyses of a series of samples selected on the spot, by a careful examination might reveal the origin of the vanadic acid.

Vulture district, as I have called it, another and quite distinct district in Arizona, has furnished, at a number of places, vanadinite with other rare species. This area embraces the country between the Hassayampa River on the west and Agua Fria on the east, and extends in a north and south direction from the well known Vulture Mine to Antelope Mountains, Weaver district, on the road to Prescott. It is

partly in the lower portion of Yavapai County, and partly in the northern portion of Maricopa County. Within this area are numerous veins of gold-bearing quartz carrying lead and sometimes a little copper or perhaps both at the same time. I have become familiar with the mineralogical character of these veins through Mr. G. A. Treadwell: and Mr. Edward Farley, owner of some of the mines which have furnished the most interesting species of this area, has prepared for me a sketch map on which the localities are laid down with sufficient accuracy for identification by reference to the Government map.

Farley's "Collateral Mine," about twenty miles northeast of Vulture, is perhaps the most interesting locality of vanadinite in this area. The vein is about four and a half feet wide, and occurs in soft gray talcose rock. About one-half of the thickness of the vein, on the hanging wall side, is quartz stained green with chrysocolla, and chocolate-brown with a ground-mass which I find carries vanadium, and showing lemon-yellow stains resembling plumbic ochre, also a vanadate. Any portion of these yellow and brown masses (if pulverized, digested with dilute nitric acid, and the filtrate treated with ether) gives a strong reaction for vanadic acid. Unless led to test this gangue-stone for vanadium by the occurrence of vanadinite in other parts of the vein, no suspicion of its presence would be aroused. A seam of very red ferric oxide with calcite follows next, and the red oxide of iron reacts decidedly for vanadium, while the calcite is penetrated with yellowish and white fibrous crystals of vanadinite. Next, there is a seam, of about six inches, of very soft material filled with abundant lemon-yellow acicular crystals of vanadinite in tufts and aggregated masses, the whole quite friable, forming the center of the vein, which also carries in this zone masses of cerusite. The whole mass of this soft material reacts very strongly for vanadic acid. Then follow, on the foot wall, about twenty inches of vein-matter composed of quartz with calcite. The calcite is penetrated with acicular crystals of vanadinite arranged in threads and in stellar tufts, usually not over a line in thickness, but occasionally opening into small cavities, like geodes, lined with distinct hexagonal prisms of this species. The common color is yellow but they are often nearly white. The cleavage fragments of calcite carrying the vanadium crystals form specimens of rare beauty. Quartz, similar to that in the upper section of the vein, is found in this lower member, and this is also somewhat stained with copper silicates. In its open joints occur hexagonal crystals of vanadinite of a fine yellow color; they closely resembling mimetite, but give no arsenical reaction, and I failed to obtain

a trace of arsenic from the included crystals in the calcite, when tested by soda and potassium cyanide in the closed tube. This quartz carries crystals of vanadinite in habit very unlike those which occur at the Hamburg mine in the Yuma district; they are long slender needles hardly a line in thickness, of a delicate straw-yellow color, quite transparent. They are associated with others of a rich orange-yellow color and not so well defined. There are also confused tufts of crystals of the same species, not thicker than hairs, of a pure chrome-yellow color, implanted in cavities in the red iron-stained gangue.

Descloizite (?)—A mineral which may prove to be descloizite, occurs among the ores of the Collateral Mine which have reached me. It is found in blue-black and brownish-black semi-transparent and very brilliant crusts, the individuals imperfectly developed; hardness about 3—3·5; streak-yellow to brownish-yellow. Alone in the closed tube it fuses and gives off abundant water. It reacts very strongly for vanadium and for lead, also for copper, manganese and zinc. Since this paper was in hand I have received from Mr. Farley, under date of June 25th, additional specimens of this mineral not only from the "Collateral" but also from the "Chromate" veins near the former, on one of which are seen very well defined, but very small tabular crystals, the study of which will probably show them to be the species indicated. They resemble some of the forms figured by Websky from La Plata, province of Cordoba.* We must await the arrival of more specimens before the study of this interesting mineral can be completed.

Volborthite (?)—A single well characterized specimen provisionally referred to this species came among the products of the Collateral Mines. It exists in small botryoidal masses adhering to the polished faces of deep red quartz crystals. The streak is bright yellow. In thin scales the mineral is transparent and of a clear olive-green. The luster is vitreous and dull. No crystals were detected. Alone in the matrass it fuses readily, adhering to the glass. It gives off no water and dissolves in dilute hydrochloric acid to a greenish solution from which alcohol throws down the lead in tufts of plumbic chloride. On charcoal it fuses to a black shining bead which alone gives off lead fumes and copper appears on crushing the bead in the agate mortar. With soda it gives a globule of lead enclosing one of copper. Zinc oxide stains the coal when the assay is gently heated. It may be that it will turn out to be a new species.

An anhydrous cryptocrystalline mineral containing vanadium occurs among the "Collateral" ores. It varies in color from light yellow-brown to black-brown; gives the reactions for

* Monatsbericht der Akad. zu Berlin, July, 1880, 672.

Domeyko's *chileite*, but it is not a clay-like mineral. It yields readily a globule of lead containing a nucleus of copper. No arsenic was found. It occurs also in the "Chromate" vein.

Gold in coarse crystalline grains occurs in the quartz of the "Collateral" vein.

The Phœnix Mine, one mile east of the mine last named, furnishes specimens similar to those just described. The vanadinite is light yellow and deep orange-yellow to reddish, in large, well-formed crystals, which react for chlorine but not for arsenic. The gangue is quartz which carries gold but no calcite in the samples which have reached me.

Among the specimens sent to me by Mr. Farley on the 25th of June, which I have just examined, I find crystals of vanadinite in the gangue of both the "Collateral" and the "Chromate" veins, quite unlike those before described and very closely resembling in habit, color and form, the brilliant red crystals from the Hamburg mine in the Yuma Silver District.

The Montezuma lead mine, eleven miles east of Vulture and southwest of Collateral, abounds in vanadinite which occurs in drusy crusts of a rich deep yellow and brown color on masses of cerussite. Observed with a lens these crusts are seen to be well defined hexagonal prisms. It appears to be an abundant source for the supply of vanadium.

At "the Frenchman's Mine," a gold-bearing vein, of about 18 inches thickness, consists of deeply iron-stained quartz, showing amorphous yellow-green masses of a mineral very rich in vanadic acid, and reacting for lead, copper and chlorine. It is also hydrous. It may perhaps be *mottramite*. There is a buff colored amorphous substance with it also rich in vanadinite. Calcite occurs in the gangue.

There are other localities in this district in which vanadium is found, but the foregoing will suffice.

Mimetite occurs in considerable masses north of the Domingo mine on Castle Creek in the extreme northwest of the Vulture District, as here described. I have seen only a single mass of about 80 grams found by Mr. Farley. It was without gangue or associated species, and quite amorphous.

From "Bethesda Mine," in Los Cerillos, New Mexico, I collected in April, 1880, specimens showing greenish crusts of vanadinite in botryoidal forms and sometimes nearly black. It is there associated with wulfenite and cerussite. This vein is the southerly extension of the "Mina del Tiro," worked by Mexicans of old.

It is interesting to note the wide area over which this species is now known to exist, compared to the single locality at Zimpan, in Mexico, where Del Rio in 1803 first identified it. No doubt it will be found in equal or yet greater abundance at

other localities as the work of exploration goes on. Many years since, in a paper on the Mineralogy of the Wahsatch and other Utah ranges of mountains,* I called attention to the occurrence of the molybdate of lead (wulfenite), as replacing the phosphate (pyromorphite) among the salts of lead, the latter being rarely if ever found there. Subsequently the wulfenite of Tecoma and of Eureka, in Nevada, confirmed this generalization, and I have since had very frequent occasion to notice the wide distribution of wulfenite in New Mexico and Arizona. We may now add vanadic acid as having the same wide distribution.

Wulfenite crystals of rare beauty are found in the "Red Cloud" Mine, already mentioned as furnishing the vanadinite. The specimens sent me are from a depth of about 300 feet. They show very solid tabular crystals of large size, brilliant luster, and rich orange-yellow to orange-red color. The color at once suggests the presence of vanadic acid, like the well-known specimens from Wheatley Mines as detected by Smith. But I have not found a trace of vanadic acid in these Red Cloud or other Arizona wulfenites From the "Melissa Mine" in Silver District adjacent to the Red Cloud, wulfenite is found in octagonal prismatic forms, the basal plane being almost wanting, in some specimens, giving them the appearance of simple octahedrons. This interesting form I believe has not been before observed in any American locality. The color of the species at this locality is pure orange-red; the gangue is brown, almost black, calcite. The "Rover" is another mine of the same district which furnishes wulfenite nearly identical in form with the Red Cloud specimens, but of a little lighter orange-red color.

Crocoite-group.—Three if not four of the species of this group occur among the ores of the Vulture region, and especially in the "Collateral" and "Chromate" veins. These two veins together with the "Blue Jay" and the "Phœnix mine," form a group of singular mineralogical interest, furnishing, among more common minerals, the species, crocoite, phœnicochroite, vauquelinite, joassite (?), vanadinite, volborthite (?), Descloizite (?), Chileite (?), wulfenite. *Vauquelinite* occurs quite abundantly associated with galenite and crocoite in a gold quartz gangue or vein stone. The genesis of the chromate is very manifest. The nucleus of unaltered galenite is surrounded with a bright pea-green and apple-green areola of vauquelinite, sometimes semi-transparent, and uncrystalline. This green mass is succeeded by crystalline and transparent crocoite of orange-red and cinnabar-red color giving the familiar scarlet and chrome yellow streak. The crocoite as yet has not been found well crystallized. Besides the associated species already named, occur cerusite, gold

* This Journal, III, iii, 195.

and magnetite. The magnetic sand collected in washing the gold out of the crushed vein stone was examined for chromite without success.

It is an interesting question, whence came the chromic acid? Perhaps an analysis of the galenite may detect chromium in that species. Smith has described a meteoric chromium sulphide, Daubréelite,* and there is no chemical reason why this species may not coëxist with galenite. In the paragenesis of the chromates in this district the change has evidently proceeded from without inward, and the occurrence of specimens in which the whole of the galenite is transformed is not unfrequent, as also the change of the crocoite to the lemon-yellow phœnicochroite.

Small orange-yellow crystals occur in the vauquelinite of the Vulture region, which may be the *joussite;* but more study is required before they can be proved to be this mineral.

In conclusion I will add that before the study of these interesting localities can be complete a personal visit must be made by a mineralogist to the mines, and sufficient material obtained on the spot to allow of chemical analyses.

2. Thenardite from Rio Verde, Arizona Territory.

Some months since I received a lump of a saline mineral marked "Salt," reported by my informant, Mr. Treadwell, of Phœnix, to occur in abundance on the River Verde, in Maricopa County. It proved, on examination, to be anhydrous sodium sulphate or *thenardite*, a species which has hitherto been found in very limited quantity. In an analysis in the Sheffield laboratory under the supervision of Prof. O. D. Allen, by Mr. Geo. M. Dunham, its constitution was found to be as follows:

	I.	II.
Chlorine	0·095	0·097
SO_3	56·410	56·310
CaO	0·120	0·130
MgO	0·021	0·023
Na_2O	[42·964]	[43·070]
Insoluble	0·390	0·370
	100·000	100·000

I. $Na_2O : SO_3 = 6·91 : 7·02$; II. $Na_2O : SO_3 = 6·93 : 7·01$.

The mineral is therefore nearly pure Na_2SO_4. The insoluble matter out, the impurities are only 0·24 per cent of the mass.

The specific gravity of a fragment quite free from visible impurity, taken in petroleum, I find to be 2·681. This mineral occurs in large masses, some of which, in the rough, are distinctly crystals with imperfect faces, showing eminent cleavage in the direction of the basal plane of the prism and a hackly cleavage in the opposite direction. The "insoluble"

* This Journal, III, xii, 109.

matter (=0·38 per cent) in the mineral—chiefly clay, gives it a prevailing shade of yellowish gray. Its hardness is below that of calcite; luster vitreous; fracture conchoidal to hackly.

Occurring in an almost rainless country, it has suffered little change, small portions only at surface being altered to a dry white powder of exanthalose, Na_2SO_4, $2H_2O$.

As this is, so far as known, the only locality of this species where it exists in great abundance, I have taken steps to secure all the information available respecting it. Mr. Thos. F. Hopkins, of Vulture, Arizona, has forwarded to me the following statement which I present in his own words, in a letter dated—

"VULTURE MINE, A. T., June 18, 1881.

"Mr. Boyd, a resident of the Verde Valley during the past five years, is quite familiar with the large thenardite deposit, and furnishes the following details.

"The 'Salt Mine,' as it is popularly called, is situated about two and one-half miles southwest of Fort Verde (the present post), on the west side of the Verde River. Squaw Peak is distant eight miles from Fort Verde, and this mine lies between these two points.

"It occurs on a 'bench' about fifty or sixty feet above the Verde River, and itself forms one of a series of benches gradually sloping toward the river. The deposit crops out boldly in the face of the bank, and seems to extend along a distance of from eight hundred to one thousand feet. It occurs in a white chalky-looking formation, and the surface opening is probably about ten feet wide. From this opening immense masses have been carried away during more than five years past, every rancher of the district taking off huge wagon loads for the use of his stock, etc. The deposit is solid, and is removed by blasting. It is not under water at any time, for both its sloping situation and its elevation above the river forbid such a condition.

"No systematic openings of the deposit have ever been made, and hence its extent is not known. It is simply 'gouged out' according to the whim and convenience of each new comer; but it seems practically inexhaustible."

I am informed by several persons who have seen this thenardite used for the salting of cattle—among them my friend Mr. James Douglass, Jr., who was recently in that portion of Arizona—that the animals resort to it very freely, licking it as they are wont to do common salt, and with only good results.

Thenardite has been found in Nevada and elsewhere in the arid regions of the West Coast, but not before in sufficient quantity to be of commercial importance.

G. vom Rath (Zeitsch. f. Kryst.,) has lately named Lake Balschasch, in Central Asia, as a locality the flat shores of which furnish *thenardite* in very considerable quantity.

New Haven, July 8, 1881.

ART. XXXIII.—*Liquefaction and Cold produced by the mutual reaction of Solid Substances;* by Miss EVELYN M. WALTON.

THE mixing of two dry, finely-powdered salts, one or both containing water of crystallization, is often attended by liquefaction with decrease of temperature which in many instances is very marked; and sometimes there is also a decided change in color.

A transparent, homogeneous liquid is sometimes, though rarely, obtained, but generally the liquid holds in suspension an insoluble compound or an undissolved salt either in the hydrous or anhydrous state; and sometimes the consistency is that of a stiff paste.

History.—It has long been known that freezing-mixtures may be made by mixing some salt with ice or snow, and in 1875–6 Guthrie* determined the lowest attainable temperature of quite a large number of such mixtures.

He found that the lowest temperature obtained with any given salt was the same whatever its initial temperature; also that within certain wide limits this was independent of the proportions used.

The earliest allusion I find made to freezing-mixtures, formed by the use of salts only, is in the ninth volume† of this Journal, where Ordway, in a paper on *Nitrates*, mentions experiments in which the mixture of ammonium bicarbonate with hydrated iron nitrate and with hydrated aluminum nitrate was followed by a reduction of temperature from 58° to −5° F., and from 51° to −10° respectively. Subsequently‡ he mixed nitrate of iron with Glauber's salt and obtained a reduction of 32° Fahr.

Berthelot, in his recent work on Thermo-Chemistry, devotes a brief space to the subject, and the Comptes Rendus, vol. xc, pp. 1163, 1282, contains a communication from Ditte calling attention to this wonderful phenomenon. He considers the use of concentrated acids with hydrated salts, also mixtures composed solely of salts. An example is given of ammonium nitrate and hydrated sodium sulphate mixed together in a mortar, the loss of heat being about 20° C.

Liquefaction of Salts.—As far as we know, when any salt soluble in water is mixed with ice liquefaction is sure to follow, and the minimum temperature is below 0° C. But, when salts only are taken, the case is different.

In some instances liquefaction is very evident, in others there is none at all, and in still others it is doubtful; while the

* Phil. Mag., xxix, 314. † II, ix, pp. 30, 31, 33. ‡ II, xxvii, p. 15.

loss of heat is sometimes great, sometimes very slight, according to the amount of liquefaction. Whether moistening will take place or not must be decided in nearly every case by actual trial, and in the preliminary experiments made with reference to this point I have mixed the substances in a wedgwood mortar.

From a large number of trials the following conclusions have been drawn :

1. As a rule it is necessary to liquefaction that one of the solid substances used should be hydrated.

2. It is not necessary that each solid should be a salt. Moistening sometimes follows the mixing of a salt with an acid, a salt with a base, or a base with an acid.

Ex.—Calcium chloride ($CaCl_2 . 6H_2O$) with tartaric acid ($C_4H_6O_6$).
Sodium sulphate ($Na_2SO_4 . 10H_2O$) with potas. hydrate (KOH).
Potassium hydrate (KOH) with tartaric acid ($C_4H_6O_6$).

3. As when in the case of liquids, metathesis will take place if a compound insoluble in the menstruum can be formed, so with solids, if such a compound can result, metathesis is probable with liquefaction.

4. If, by mixing two salts, an insoluble compound is produced, a mixture of two others like the new ones formed will not, as a general thing, be attended by liquefaction.

5. When no insoluble compound is formed four bodies are probably contained in the product, metathesis being partial; for it is sometimes observed that liquefaction seems equally marked whether the two original salts are mixed or the two bodies formed by their interchange.

6. The rule among liquids in regard to weak and strong acids and bases seems to prevail with solids also, their action tending to promote or impede liquefaction.

7. When, by the admixture of two salts, oxydation or reduction can take place, there is again probability of liquefaction.

Ex.—$SnCl_2 . 2H_2O$ with $HgCl_2$ liquefied.
" " $Fe_2Cl_6 . 12H_2O$ "
" " $CuCl_2 . 2H_2O$ "
" " $PbCl_2$ no liquefaction.

In the last no change by reduction is possible.

A new substance.—A notable exception to the rule mentioned above, that one salt at least should be hydrated, is that of $AgNO_3$ mixed with $HgCl_2$. When these are rubbed together there is decided moistening, which would seem to prove that there is such a body as anhydrous nitrate of mercury liquid at ordinary temperatures. On adding water a large residue of silver chloride is observed.

Evidences of chemical change.—When salts capable of metathesis are mixed, in addition to liquefaction, change of color, formation of an insoluble compound, and escape of a gas are proofs of chemical reaction.

An important difference sometimes noticed between mixtures of salts in the solid and the liquid form is the escape, in the former case, of some gas, as $C_2H_4O_2$, CO_2, HCl or NH_3. The gas is dissolved by a liquid solution and eludes observation.

Classification.—Cases of liquefaction may be divided into two classes; the first including those in which there is mutual exchange of base or acid; the second, those in which there is no interchange.

The mixture of lead nitrate with sodium carbonate is an example of the first class. There is metathesis, and we obtain lead carbonate, sodium nitrate, and ten equivalents of free water.

$$Pb(NO_3)_2 + Na_2CO_3 . 10H_2O = PbCO_3 + 2NaNO_3 + 10H_2O.$$

Hydrated product.—When iron nitrate is mixed with calcium chloride thirty-six equivalents of water in some form are obtained.

$$Fe_2(NO_3)_6 . 18H_2O + 3[CaCl_2 . 6H_2O] = Fe_2Cl_6 + 3Ca(NO_3)_2 + 36H_2O.$$

Having mixed equivalent weights, the product was dried on the smooth surface of a plate of plaster of paris which absorbed the moisture, and an analysis showed the two new salts obtained to be hydrated.

Therefore,

$$Fe_2(NO_3)_6 . 18H_2O + 3[CaCl_2 . 6H_2O] = Fe_2Cl_6 . 12H_2O^* + 3[Ca(NO_3)_2 . 4H_2O] + 12H_2O.$$

This experiment was repeated with a mixture of $Fe_2(NO_3)_6 . 18H_2O$ with NaCl; also of $Ca(NO_3)_2 . 4H_2O$ with $MgSO_4 . 7H_2O$, and the first product was found to contain iron chloride, the second nitrate of magnesium, both in the hydrated form.

At the more or less low temperature due to liquefaction, there is naturally a tendency for salts to crystallize out from the saturated solution.

The crystalline character is sometimes perceptible to the senses, for the product often contains grains much coarser than did the finely-powdered salts first taken.

Effect of temperature.—Experiments show that sometimes liquefaction takes place readily at a temperature somewhat elevated, but not at all at a low temperature. A mortar and

* It was found that $Fe_2Cl_6 . 12H_2O$, and not $Fe_2Cl_6 . 6H_2O$, was formed.

pestle which had been warmed by hot water were occasionally used, care being taken that the heat should not be great enough to cause either of the original salts to melt in their water of crystallization.

When two salts capable of metathesis are mixed, chemical action apparently begins immediately at every point of contact. But there is a limit to the fineness of division which may be effected by mechanical means, and the substance consists of minute grains coated on the outside with the new product, while remaining unchanged at the interior.

When liquefaction ensues, the interchange is continued either because by removing the particles of the product, new surfaces are presented, or because the liquid, penetrating the granules, separates them into their molecules.

If the salts taken furnish little or no water in excess of that required to combine with the new ones formed, the process of interchange apparently soon ceases, unless sufficient heat is supplied to prevent the constituents of the product from assuming the solid form.

Difficultly soluble salts.—When salts difficultly soluble are used, moistening follows but slowly if at all. The molecules of such substances are not easily separated with a limited supply of water, especially at a reduced temperature.

Liquefaction without chemical reaction.—The second class referred to above includes mixtures of salts of the same base, or having the same acid; and although it seems to be the exception rather than the rule that there should be liquefaction in such cases, yet this sometimes occurs.

Ex. —	$Fe_2Cl_6 . 6H_2O$	with	$Fe_2(NO_3)_6 . 18H_2O$	liquefied.
	$Fe_2Cl_6 . 12H_2O$	"	"	"
	$FeCl_2 . 4H_2O$*	"	"	"
	$FeSO_4 . 7H_2O$	"	"	"
	"	"	$Fe_2Cl_6 . 6H_2O$	"
	$Na_2C_2H_2O_2 . 6H_2O$	"	$PbC_2H_2O_2 . 3H_2O$	"
	"	"	$K_2C_2H_2O_2$	"
	"	"	$ZnC_2H_2O_2 . 3H_2O$	"
	$Na_2SO_4 . 10H_2O$	"	$ZnSO_4 . 7H_2O$	"
	"	"	$Li_2SO_4 . H_2O$	"
	$CaCl_2 . 6H_2O$	"	$Fe_2Cl_6 . 12H_2O$	"
	"	"	$CuCl_2 . 2H_2O$	"

Some interesting experiments with caustic soda (NaOH) showed that when it was used with any hydrated sodium salt the combined water was liberated, evidently to satisfy the affinity of NaOH for water.

KOH was also used with various hydrated salts, and in

* Of course a ferric and a ferrous base are not strictly the same, but ferrous nitrate is too unstable a body with which to work except in the coldest weather.

every instance liquefaction ensued. Apparently the hydrated salt was attacked for the sake of its water, and the first reaction seems to be appropriation of water by KOH, which is doubtless followed by metathesis in most cases.

Liquefaction in the examples given above, however, cannot be explained in this way. Neither is there metathesis, and evidently double salts are not formed.

Having mixed equivalent weights of $ZnSO_4 . 7H_2O$ and $Na_2SO_4 . 10H_2O$, the composition of the resulting solid part was found not to be that of a double sulphate, there being an excess of Na_2SO_4.

Equivalent weights of $CaCl_2 . 6H_2O$ and $Ca(NO_3)_2 . 4H_2O$ were mixed, also of $Fe_2Cl_6 . 12H_2O$ and $Fe_2(NO_3)_6 . 18H_2O$, with a view to analysis, but in each case the thin liquid disappeared entirely into the plaster plate used for absorption, leaving only a stain visible.

Theory.—These examples must be similar in nature to mixtures of salts with ice, which result in liquefaction, and solution of the salts.

That the cold produced when ice and a salt are mixed is due to rapid liquefaction of the ice is plain enough, but I have seen no attempt made to explain the cause of the liquefaction, until Ordway last year announced his theory of the "diffusion of solids," in an address* before the American Association for the Advancement of Science.

We know that the molecules of a body are in a state of constant oscillation, and that if a salt solution be placed in contact with pure water, diffusion takes place until the molecules of salt are equally distributed throughout the mass.

So, too, when the solid is placed in water, solution follows, or, in other words, diffusion. Now, when a salt and water, both in the solid form are in contact, there is probably the same tendency to interpenetration. But a mixture of water and salt molecules cannot remain in the solid form except at a low temperature, and the rigidity of the solid state is overcome, because oscillations of the water and the salt molecules coöperate to produce a greater motion.

Graham found that although sodium chloride is not at all deliquescent, yet the saturated solution has a great affinity for water. Therefore when the smallest quantity of the salt is once in solution the first step is taken and the melting of the ice continues rapidly. If this is the true explanation of the action of sodium chloride on ice the problem is solved.

When salts capable of metathesis are used this physical phenomenon is complicated by chemical reaction. Liquefaction probably results when $CaCl_2 . 6H_2O$ and $Ca(NO_3)_2 . 4H_2O$ are

* Proceedings Amer. Assoc. Adv. Science, vol. xxix, p. 293.

mixed, and in similar cases because the crystallizing point of these two bodies together is lower than for each alone; just as the freezing point of salt water is lower than that of fresh water, and as the fusing point of an alloy is sometimes below that of either of its constituents.

Calorimeter.—For further experiments in which the reduction of temperature might be measured with some degree of accuracy, it was desirable to secure a closed space in which radiation and convection should be reduced to a minimum, and the heat of the surroundings should be constant. A calorimeter was therefore constructed somewhat like that used by Berthelot in some of his investigations.

It consists of a covered circular tank of fourteen-ounce tinned copper, of about twelve gallons capacity, placed in a much larger wooden case, the space between the walls of the tank and case being filled with loose cotton.

The upper surface of the tank has four wells, each to receive a cylindrical vessel of polished german silver resting on cork supports and having an air space around and under it. Each of these vessels, containing a glass beaker of smaller diameter (also on cork rests), is furnished with a closely-fitting cork cover, perforated to admit a thermometer and a slender wooden stirrer consisting of an upright rod with cross arms at bottom, like a pug-mill.

The thermometers have each a long stem with the scale on the upper part so that readings even to $-40°$ C. can be taken without raising the bulb from the mixture.

The tank is kept filled with water,* and this is frequently agitated by a stirrer moved with a crank. The stirrer revolves horizontally in the bottom of the tank, and having two blades like a propeller, it agitates the water thoroughly from bottom to top, the moistened part being always immersed. Over the whole is a closely-fitting wooden cover also perforated for the thermometers and stirrers.

The salts to be mixed, after finely pulverizing, were placed in separate beakers within the calorimeter, and left for a time to acquire a uniform temperature. The contents of one beaker were then added to those of the other, the cover replaced as quickly as possible, and the whole mixed vigorously by twirling the stirrer. Liquefaction generally took place in five to ten minutes and observations of time and temperature were then taken, slight agitation being still continued. There being four beakers two experiments can be carried on at the same time, and as the cover is not in a single piece one portion can be removed without uncovering the other pair of beakers.

* Water of any desired temperature may be used.

Equivalent weights were taken, seventy grams being used at first, but this was afterward increased to one hundred grams.

From the following observations it will be seen that the amount of radiation and convection is so small that it may be disregarded:

Mixture of $Mn(NO_3)_2 . 6H_2O$ with $Na_2CO_3 . 10H_2O$. Temperature of water of calorimeter, 18° C.

Time.	Temperature.
0 min.	19° C.
4	— 9°
5	—10°
6	—10·5°
10	—10·5°
11	—10°
21	— 7°
25	— 5°

Six minutes were required to reach the lowest point and during the next five minutes there was a gain of but 0·5°. Stirring was stopped at the end of eleven minutes.

Lowest attainable temperature.—In addition to Guthrie's discoveries already mentioned, he found that when two salts were used with ice the minimum temperature was unlike that of either alone, each exercising an influence over the other.

Most of my experiments with the calorimeter were made for the purpose of discovering whether or not the lowest attainable temperature of a given salt when mixed with ice is the same if that salt is produced in a freezing-mixture of two salts; also if it is independent of the initial temperature and the proportions used.

The hydrated sulphate and carbonate of sodium were each mixed with various nitrates, whereby nitrate of sodium was produced and a sulphate or carbonate, usually an insoluble compound, which I thought could not influence the result.

The lowest attainable temperature of sodium nitrate with ice is −17° C.

The following results were obtained with metals whose carbonates are without doubt anhydrous, insoluble compounds:

			Initial temp.	Lowest temp.	Loss.
$Pb(NO_3)_2$	with $Na_2CO_3 . 10H_2O$		19° C.	−17°	36°
"	"	"	0°	−17°	17°
$Ba(NO_3)_2$	"	"	21·3°	−13·7°*	35°
"	"	"	−1°	−17°	16°
$Al_2(NO_3)_6 . 18H_2O$	"	"	14°	−18°	32°
"	"	"	−4°	−18°	14°
$Cu(NO_3)_2 . 6H_2O$	"	"	16·5°	−18°	34·5°
"	"	"	−2°	−15°†	13°

* An insufficient quantity was taken. † Liquefaction proceeded very slowly.

With the nitrates of zinc, manganese, iron and chromium the results were not so free from modifying influences as I had anticipated, basic carbonates being formed not wholly insoluble at low temperatures.

The interesting fact was thus revealed that ferric carbonate or basic carbonate exists in the liquid form at a low temperature, say −20° C. The color is a deep red, and as the mixture gradually warms CO_2 is rapidly given off, causing the contents of the beaker, which was not at first more than half filled, to overflow and insoluble Fe_2O_3 to be deposited.

		Initial temp.	Lowest temp.	Loss.
$Mn(NO_3)_2 . 6H_2O$	with $Na_2CO_3 . 10H_2O$	18°	−14°	32°
"	"	− 2°	−26°	24°
$Zn(NO_3)_2 . 6H_2O$	"	20°	−16·7°	36·7°
"	"	− 1°	−21·5°	20·5°
$Cr^2(NO_3)_6 . 18H_2O$	"	− 3°	−22°	19°
$Fe_2(NO_3)_6 . 18H_2O$	"	13·5°	−17°	30·5°
"	"	10·5°	−17°	27·5°
"	"	− 3°	−24°	21°

It will be seen from these and the following results that the minimum temperature is not independent of the initial temperature; it was also found that the lowest point varies with the proportions taken:

		Initial temperature. 1st.	2nd.	Lowest temp.
$Pb(NO_3)_2$	with $Na_2CO_3 . 10H_2O$	45°	22°*	−12·5°
$Fe_2(NO_3)_6 . 18H_2O$	"	39°	32°	− 4°
$Al_2(NO_3)_6 . 18H_2O$	"	37°	32°	− 2°

With the nitrates of magnesium and calcium the tendency to metathesis is so slight that the liquefaction is not rapid enough to produce any great degree of cold, and with an initial temperature of −2° there is no liquefaction whatever.

The time allotted for the completion of my graduation thesis, of which this paper gives the substance, rendered it necessary to suspend for the present the continuation of these experiments. This work was undertaken at the suggestion of Professor Ordway, to whom the subject has been one of interest for some years, but whom the pressure of other duties has prevented from pursuing an investigation. He has, however, given considerable thought to the matter, one of the results of which is his theory of the "diffusion of solids." His predictions that there may be liquefaction without chemical reaction, and that the product obtained from the mixture of salts is sometimes hydrated, were both confirmed by the results of my work. He devised the calorimeter which was used, and I am indebted to him also for valuable suggestions and advice.

Mass. Inst. Technology, June 3, 1881.

* The temperature of $Na_2CO_3 . 10H_2O$ could not be raised so high as that of the other salts, without melting.

ART. XXXIV.—*On the Spectrum of Arsenic;* by OLIVER W. HUNTINGTON. With Plate IV. (Contribution from the Physical Laboratory of Harvard College.)*

IT has been noticed, in the case of the spectrum of nitrogen gas, that the spectrum obtained from an electric discharge of low intensity through a rarefied atmosphere differs from that obtained when the intensity of the discharge has been increased by a Leyden jar. In the case of the low tension discharge, the bands of the spectrum appear fluted on the more refrangible side; but upon the introduction of a Leyden jar into the circuit the fluted appearance at once vanishes, and the spectrum breaks up into isolated bands. This difference has been ascribed to a difference of condensation of the molecule. Now as arsenic is allied to nitrogen, it was thought the same difference might appear in the spectrum of arsenic, and we proposed to make this a subject of investigation, For this purpose, we first prepared two tubes,—one an ordinary Geisler tube, such as is used for showing the spectrum with rarefied gas; the other as shown in fig. 1 of accompanying plate, for the spark spectrum with Leyden jar. A small amount of pure metallic arsenic was introduced into each tube, and they were then repeatedly exhausted, each time replacing with hydrogen. After the final exhaustion, the tubes were heated, in order to fill them with the vapor of arsenic. But, upon passing the spark through them, we could obtain no definite or satisfactory result. The arsenic spectrum was feeble, the hydrogen brilliant, and the fluted indefinite bands which accompany the hydrogen spectrum wholly obscured the phenomenon.

Judging from the statements in Roscoe's spectrum analysis that these fluted portions of the hydrogen spectrum were accidental and due to impurities, we attempted to get rid of them in order to bring out the arsenic spectrum. We, therefore, prepared several tubes with pure hydrogen. We arranged tubes with two outlets, in order to pass a continuous current through the whole apparatus, including the Sprengel pump which was connected with one of the openings. The hydrogen was prepared from pure zinc and sulphuric acid, and most carefully dried. We would allow the gas to slowly pass through the apparatus for twenty-four hours, then exhaust, and after exhaustion heat the tube as hot as practicable under the circumstances, then pass dry hydrogen and repeat the process several times. Notwithstanding these precautions, we found, after a great many trials with different tubes, that the fluted

* From the Proceedings of the American Academy of Arts and Sciences, Boston, 1881, p. 35.

and more or less diffused spectrum always accompanied the four principal hydrogen lines. It being then impossible to eliminate the diffused spectrum, we next tried alloying the platinum electrodes with arsenic, and experimented with these in a rarefied atmosphere of hydrogen, both with continuous discharge of Ruhmkorff coil, and with interrupted discharge with Leyden jar. We now obtained very definite arsenic bands, apparently the same in both cases; but the effect was momentary, and gave no opportunity for measurement. The spectrum while it lasted was very striking; but, as soon as the arsenic on the extreme point of the electrode passed off, the characteristic spectrum disappeared.

We were by this experience led to contrive the following apparatus, by which we obtained the desired result, and the same may be useful in experiments on the spectra of similar volatile substances. A longitudinal section of the tube, one-half of the original size, is shown in fig. 2 of plate. The portions AA′ and A″ are of rather coarse thermometer tubing. BB′ is a tube left open at B, and drawn to a capillary point at B′. The substance to be examined, after being reduced to powder, is introduced through the opening at B until the tube is about half full. Then one end of a platinum wire is buried in the substance, and the other end is fused into the tube at B, thus closing the opening. After the hydrogen has been allowed to flow through the tube a sufficient length of time, the opening at A is closed by a nipper-tap, and the tube is exhausted at B″. Now upon connecting B with the negative electrode, and C with the positive electrode, of a small induction coil, we have the vapor of the substance in the tube BB′ carried in the current through the tube A′ where the spectrum may be observed.

One advantage of this particular form of tube is, that, in order to compare the spectrum of the substance with that of hydrogen, we have only to reverse the current, making C the negative pole, and then all the lines except those of hydrogen at once disappear.

The arsenic spectrum thus obtained is very brilliant, and consists of numerous well-marked sharply defined bands. The bands are most numerous and brilliant in the green, and these give the prevailing tone to the spectrum. But there is one very striking yellow band, and there are also several bands in the blue and violet. Then in the red there is an interesting double band, the two members of which are the same distance apart as the two D lines. In addition, there may be also a more or less diffused spectrum, which in some parts cannot be distinguished from the similar diffused spectrum of hydrogen, and it is worthy of remark in this connection, as indicating the

purity of the material used, and also that the diffused spectrum above referred to cannot come from the material of the tube, that no trace of the sodium line was seen. No account was taken of the diffused spectrum, as it appeared only when the battery was unusually strong.

In speaking of the diffused spectrum of arsenic, we do not mean the same kind of diffused spectrum as mentioned above in connection with nitrogen. The diffused arsenic spectrum appears to be composed of innumerable faint lines, wholly independent of the other more brilliant characteristic arsenic bands; and we use the term "diffused" only for convenience, to express that the lines are very faint and too numerous to measure. And we wish to call particular attention to the fact already intimated, that the spectrum of arsenic as it appears with the silent discharge bears no resemblance to the fluted spectrum of nitrogen, but consists of sharply defined isolated bands, the more prominent of which, at least, are not altered when the intensity of the discharge is increased by a Leyden jar.

The arsenic employed had been carefully purified by sublimation, and preserved under distilled water. We used for measuring the wave-lengths of the spectrum lines the spectroscope described by Professor J. P. Cooke.* In this instrument, the train of prisms can be adjusted accurately to the angle of minimum deviation, which was observed in each case. We used five flint prisms of 45° angle each, and to reduce the angular measurements to wave-lengths, we employed the method described by W. M. Watt in his "Index of Spectra."

In the first place, we measured with care the angles of minimum deviation of the most prominent Fraunhofer lines, and verified and somewhat multiplied the data by measuring also the angles for characteristic lines of the hydrogen, lithium, sodium, thalium and strontium spectra. These we combined with the wave-lengths of the same lines given by Ångström, by ordinates and abscissas in the usual way, and the curve drawn through the points so determined was so regular and of so small curvature, that it was easy to interpolate with minutes of arc to five *tenth-metres* of wave-length, as usually expressed.

The instrument is capable of reading to five seconds of arc, and with the full bank of ten prisms it would give the wave-lengths to tenth-meters with perfect accuracy. With the comparatively feeble light of the arsenic spectrum, as we first observed it, we did not think it advisable to use the full power of the instrument. We therefore used five prisms, as stated, and read to one minute of arc. We always began each series of observations by setting the cross-wire of the micrometer on

* This Journal, xl, November, 1865.

the sodium line, after the telescope had been adjusted to the angle of minimum deviation of this line as first observed. There was seldom any observed difference in this angle. But when, by change of temperature, or otherwise, an alteration of two or three minutes had taken place, we found, on readjusting the cross-wire, that the relative position of the spectrum lines was, to the limit of accuracy of our measurement, wholly unchanged.

We give below the table of wave-lengths of the principal lines of the arsenic spectrum.

6023	tenth-meters.	5230	tenth-meters.
6013	"	5195	"
5853	"	5163	"
5833	"	**5103**	"
5813	"	5013	"
5743	"	4941	"
5653	"	**4623**	
5563	"	**4593**	
5498	"	4493	"
[5340]	"	4463	"
5323	"	4313	"
5245	"		

The wave-lengths printed in heavy type denote the bands which are most brilliant and give character to the spectrum. The other lines are less constant and less distinct, and in some instances may be due to accidental causes.

We were surprised to find among the bright lines, that the one which in the table is enclosed in brackets corresponds to the green thalium band, and upon examining the spectrum it appeared evident that thalium must be present in the arsenic in large quantities, as the thalium band was fully as bright as any of the arsenic bands.

The diagram, fig. 3 of Plate IV, gives some idea of the general appearance of the arsenic spectrum.

SCIENTIFIC INTELLIGENCE.

I. Chemistry and Physics.

1. *On the Spontaneous Oxidation of Mercury and other Metals.*—Berthelot has submitted to experimental verification the question so long discussed without final settlement, whether mercury dissolves the oxygen of the air and oxidizes, even at ordinary temperatures. Perfectly pure mercury was placed in a rectangular dish of porcelain exposing a surface of 500$^{cm^2}$ about, and covered loosely with paper. After 48 hours at a temperature of 10°, the metal yielded a slight pellicle to a tube of glass passed over it. This was removed from day to day and showed on analysis the presence of mercurous oxide. The slow oxidation of

pure mercury in contact with air can no longer be doubted. The same is true of iron, zinc, cadmium, lead, copper and tin. Now thermic data explain this phenomenon. For each equivalent of oxygen fixed by the metal, iron (rust) evolves 31·9 calories; tin 34·9; cadmium 33·2; zinc 41·8; lead 26·7; copper 21·0, and mercury 21·1. This oxidation in the air, however, is not appreciable in the case of metals whose heat of oxidation is small. Silver, for example, evolves only 3·5 calories per equivalent of oxygen absorbed. The fact that a reaction begins spontaneously only in the case where a notable evolution of heat takes place, is a result not unfrequently observed; seeming as if there was a certain resistance to be overcome, a certain preliminary work to be accomplished in order to determine the reaction. But this action becomes more prompt and more easy when an auxiliary agent is made to intervene capable of combining, with evolution of heat, with the substance at first formed; so that the total energy in action becomes greater. This is the action called in early times pre-disposing affinity. If, for example, mercury be placed in a flask and hydrogen chloride gas be mixed with the air in contact with it, the walls of the flask will be covered after a time, with mercurous chloride. Now hydrogen chloride alone does not act on mercury at all, under these circumstances; the oxygen of the air intervenes, the reaction Hg_2+HCl gas, +O=Hg_2Cl+HO liquid evolving 53·4 calories.* So silver, which is not acted on by oxygen alone, is easily converted into chloride in presence of hydrogen chloride gas in addition, the reaction Ag+HCl gas+O=AgCl+HO liquid evolving 41·7 calories. So silver in contact with air is attacked by a solution of sodium chloride, copper by hydrochloric and acetic acids, lead by acetic acid, etc. In the case of mercury and hydrogen sulphide, in presence of air, the hydrogen is oxidized, the sulphur finely divided is precipitated and acts upon the metal. The same mechanism takes place with silver.—*Bull. Soc. Ch.*, II, xxxv, 487, May, 1881. G. F. B.

2. *On Hesperidin, a Glucoside of the Aurantiaceæ.*—Tiemann and Will have examined at length a glucoside found by Pfeffer in the fruit of *Citrus vulgaris* and *Citrus medica*, and called hesperidin. It appears to be universally diffused through the family of the Aurantiaceæ and is most readily prepared from the dried, unripe officinal orange (*Fructus aurantii immaturi*). The coarsely pulverized fruit was extracted with water so long as lead acetate gave a precipitate in the extract. The residue was then treated with a mixture of equal volumes of alcohol and water, containing 1 or 2 per cent of sodium hydrate, until the solution was no longer colored. From this last solution, mineral acids precipitate crude hesperidin. This is boiled with 90 per cent alcohol to remove coloring matters and the residue is dissolved in very dilute potash solution, and precipitated by a slow current of carbon dioxide. It is well washed and dried. As thus

*The symbols in these equations represent equivalents, not atoms.

obtained, hesperidin is a white, odorless and tasteless mass, consisting of fine microscopic needles, insoluble in ether and nearly so in water. Alcohol takes up only small quantities, though by distillation off of the solvent it may be obtained in somewhat larger needles. It fuses at 251° and decomposes. On analysis it gave the formula $C_{22}H_{26}O_{12}$. It possesses weak acid properties, is soluble in alkalis and reprecipitated by acids. On heating with water and sodium amalgam for a few minutes, filtering the orange solution and adding an acid, a precipitate falls which dissolves in alcohol with a magnificent red violet color, with a blue violet fluorescence. By the action of dilute sulphuric acid hesperidin splits into dextrose and hesperitin, $C_{16}H_{14}O_6$. This, by the action of alkali, splits into phloroglucin and hesperetinic acid $C_{10}H_{10}O_4$. Fused with potassium hydrate this acid yields protocatechnic acid $C_7H_6O_4$. Methyl-hesperetinic acid, oxidized by permanganate, gives veratric acid (dimethylprotocatechnic acid). Acethesperinic acid when thus oxidized yields isovanillic acid. Hence hesperetinic acid is identical with isoferulaic acid. From these reactions the author gives the following as the rational formula of hesperetin: $C_6H_3\begin{cases}CH{=}CH\text{-}CO\text{-}O\\OH(3)\qquad(3)HO\\OCH_3(4)\qquad(5)HO\end{cases}C_6H_3$. The quantity of hesperidin which is contained in the dried fruit, about 10 per cent, suggests the importance of this glucoside to the growth of the plant.—*Ber. Berl. Chem. Ges.*, xiv, 946, Apr., 1881. G. F. B.

3. *On a new series of Volatile Organic Bases.*—Meyer and Treadwell, by the reduction of nitrosoketones by sodium-amalgam or by tin and hydrochloric acid, have produced a series of well characterized bases of the formula $C_nH_{2n-1}N_2$, which distil without decomposition and form with water crystallized compounds. The name ketines is proposed for these bases, and one member of the series, dimethylketine, has already been described by Gutknecht, who obtained the platinum salt pure.—*Ber. Berl. Chem. Ges.*, xiv, 1150, May, 1881. G. F. B.

4. *Photometry of the Fraunhofer lines.*—Vierordt employs the peculiar slit of his spectrophotometer to measure the relative intensity of the Fraunhofer lines, using the simple fact that the strength and sharpness of these lines varies with the width of the slit of the collimator. His paper consists merely of a preliminary note, and measurements are promised; he believes that the variation in light-intensity of the dark lines will prove the most characteristic feature of the spectra of heavenly bodies.—*Annalen der Physik und Chemie*, No. 6, 1881, p. 338. J. T.

5. *Intensity of Sound.*—Overbeck has endeavored to obtain quantitive measurements in acoustics by the use of the microphone. It is evident that if we possessed a sufficiently delicate electro-dynamometor an electrical measure of the intensity of sound waves could be obtained. In place of such an instrument Overbeck uses a galvanometer which is affected by the varying resistance of the microphone when the latter responds to sounds

of different intensity. It is found that the microphone, used in this way, is far more sensitive than the ear to changes of tone—that it can be used with great effect to study resonance—the reflexion of sound in different rooms, and the influence of the change of temperature upon the propagation of sound waves. The author proposes to extend his investigations.—*Annalen der Physik und Chemie*, No. 6, 1881, p. 222. J. T.

6. *Reversal of the lines of Metallic Vapors.*—Professors LIVEING and DEWAR have succeeded in reversing ten of the brightest lines of iron, in the blue and violet, by passing an iron wire through one of the carbons between which the electric arc is formed. When iron is put in a lime crucible through which the voltaic arc is formed, and fragments of magnesium are dropped in from time to time, most of the strong ultra violet lines of iron are reversed. The magnesium appears to supply a highly reducing atmosphere, and to carry the iron vapor with it. It also appears to produce a continuous spectrum in certain parts, and against this the iron lines are sometimes depicted on the photographic plates sharply reversed. Potassium ferrocyanide introduced into the arc acts in a similar manner. Iron wire fed through a perforated pole reverses certain lines (wave length 2492 to 2480) and spreads out the lines into broad absorption bands. These effects are enhanced by leading into the crucible, through the perforated upper carbon, a gentle stream of hydrogen gas.—*Nature*, June 30, 1881, p. 206. J. T.

7. *Change of State.*—There are two types of change of state which are usually recognized: the ice water type, in which the change takes place first at the surface and gradually extends, the ice remaining solid up to the melting point, and the sealing wax type, in which softening takes place throughout the entire mass, on elevation of temperature. Mr. J. H. POYNTING defends the solid liquid type theory. He shows that it is easy to give an explanation of the phenomenon of melting and freezing by supposing, on the theory of the passage of molecules, "that if the temperature is not at the melting point the substance in the state with the greater vapor-tension will lose at the expense of the state with the less vapor-tension." The alteration of the melting point by pressure is explained by the supposition that pressure alters the vapor-tension, and therefore the rate of escape of molecules, and that this alteration is different for the two states. Mr. Poynting gives, on this supposition, a new proof of Sir W. Thomson's formula, which expresses the relation between the vapor-tension at plane surfaces of a liquid and the vapor-tension of the same liquid above its surface in capillary tubes. The remarkable result is deduced that if ice can be subjected to pressure while the surrounding water is not so subjected "the lowering of the melting point per atmosphere is about 11½ times as great as when both are compressed." An account of certain experiments is given which appear to support this theoretical conclusion. A possible explanation of Professor Carnelly's "Hot Ice" is deduced from

considerations of the isothermals for ice water. The place of this "hot ice" would seem to be represented by the prolongations upward of the ice isothermals beyond the horizontal line to where they meet the line of no pressure. The critical point, which is roughly fixed at 14°C., would then be above the limit to the temperature of hot ice in a vacuum. "It is also pointed out that the sealing wax type of melting is probably similar to the change of ice into water below the lower, or above the upper, critical points, if these exist."—*Phil. Mag.*, July, 1881, pp. 32–48. J. T.

II. Geology and Mineralogy.

1. *Geology of the Province of Minas Geraes.*—From two important memoirs published by Prof. Henrique Gorceix in the *Annaes da Escola de Minas de Ouro Preto*, noticed in our last, we condense the following account of the geology of the central part of the province of Minas Geraes, Brazil.

The greater part of the central portion of the province of Minas Geraes is constituted by the great chain appropriately named Serro do Espinhaço. This chain is formed principally of quartzose and schistose rocks, to which are joined granitic gneiss and even true granites, mica schists, dikes and intercalated beds of diorite and finally small deposits of anomalous rocks containing tourmalines, disthene and other minerals.

The quartzose rocks are true quartzites consisting of irregular grains of hyaline quartz without cement. To the quartz in these rocks are united two other substances, a green mineral and micaceous iron which serve to characterize two principal geological horizons. The inferior division of the quartzites is characterized by the presence of a soft green unctuous mineral generally described as talc, but which unlike talc contains only an insignificant proportion (1 to 3 per cent) of magnesia with a large proportion of alumina, and the alkalies, potash and soda. The presence of small quantities of iron, manganese and chrome probably determines its green color. These quartzites are known by the name of itacolumites and are in the lower division characterized by a schistose or flaggy structure.

In the quartzites with the green substance two subdivisions are recognized at Ouro Preto. The lower one consists of flaggy beds which near Ouro Preto are inclined at an angle of 25° or 30° to the southward. The second and more important division constitutes the peak of Itacolumi, and consists of more massive beds with an easterly inclination. Both divisions are traversed by auriferous veins, in which the matrix is generally common iron pyrites or arsenical iron pyrites.

In some cases, as at Morro Velho, Pary, etc., quartz enters in relatively small proportions in the vein matter and the gold is very fine, and in small but constant quantity. When, on the contrary, the pyrites disappear and the vein is formed almost exclusively of quartz, the gold is in larger grains but very irregularly disseminated in the vein rock.

The second division of the quartzites is characterized by the substitution of the green matter by micaceous iron and often by the disappearance of the quartz; these pass to beds of iron ore known by the name of *itabirite.* The beds of itabirite attain in places the thickness of more than 200 metres and by the abundance and purity of the mineral and the facility of extraction constitute the richest iron ore deposits of the world. The iron is often accompanied by oxide of manganese which in places enters in a proportion as high as 9 per cent, or more.

In the friable itabirites gold is often found disposed in a manner which seems to be peculiar to Brazil. The gold appears disseminated in the rock in scales analogous to the scales of iron oxide, these scales being sometimes joined together so as to form large nuggets. The distribution of the gold in the rock appears to be irregular but it is probable that the rich lines have, like veins, a definite direction. The absence of sulphides which characterize the gold bearing rocks inferior to itabirites, is worthy of note. The only substance which appears to mark the presence of gold is a white lithomarge appearing in little pockets in the rock.

The schistose rocks are of very variable characters, and when fully studied, either from a geological or mineralogical point of view, will fall into several divisions. They are generally shales passing at times to true slates; soft, greasy to the touch and of various colors, green, yellow, red, black, etc. These schists have generally been described as talcose, but analysis proves them to be argillaceous, rich in alkalies and with but a trifling proportion of magnesia.* True talcose rocks consisting of soapstone or potstone are however met with in small basins in the midst of the schists. The schists may be divided into two groups with reference to their relations to the itabirites, namely, those below the itabirites characterized by brilliant mica-like scales, extreme softness, and a relatively small development of the schistose structure, and those superior to the itabirites characterized by a greater predominance of the argillaceous character and of the schistose structure.

These schists are everywhere metamorphosed, but in the north of the province in the Jequitinhonha and Arassuahy basins the alteration of the rocks is more pronounced than in the region farther south and the rock becomes crystalline, passing to mica schist and other types of crystalline rocks. These crystalline schists perhaps belong to another geological series. This change to the crystalline character is accompanied by the appearance of numerous veins of quartz accompanied by tourmalines, staurolites, spodumene, chrysoberyls, etc.

In the series of schists the gold-bearing veins are less numerous than in the other groups described, and are of inconstant richness. In places gold also appears distributed in the rock in a manner analogous to that in the itabirites but this only occurs in the parts contiguous to the latter rock. The group of schists is also

* These are evidently *hydromica* schists.- -EDS.

characterized by the presence of isolated masses of crystalline limestone or marble.

The determination of the geological age of these various rocks, and even that of the relative ages of the different groups, is rendered difficult by the absence of fossils, and by the excessive dislocation of the beds by folding and faulting, faults being particularly numerous and giving a peculiar character to the mountains of the region, which generally present a moderate slope on one side and a precipice on the other.

The rocks above described have been referred to the Tertiary and Secondary ages; but there are good reasons for considering them more ancient than the limestones of the São Francisco in which Prof. O. A. Derby found fossil corals which indicate that these are much older than the Secondary and belong to the Paleozoic age.

The more modern rocks are represented by the peculiar iron conglomerate denominated *canga* formed on the surface from the fragments of the underlying rocks and which continues to form to-day, and by deposits of lignite of Tertiary age as is proved by the fossil plants and fishes contained in them.

A fact of considerable interest, from an agricultural point of view, is the uniform presence of a notable proportion of alkalies, particularly potash, in all the schistose rocks examined, and the absence of lime in the same rocks. The first fact explains the wonderful fertility of many of the soils derived from the decomposition of the schists, and the second indicates the proper fertilizer for the more sterile soils.

Of the precious stones found in Minas, the deposits of topazes, situated near Ouro Preto, have been most studied. Topazes and the still rarer euclases are found in their primitive formation in a small basin west of Ouro Preto in which several mines have been opened. The rocks of this region consist of schists and quartzites with the green substance, the beds being inclined at angles of 30° to 50° to the eastward. The schists are the predominant rocks and belong to the two divisions already described of clay schists and greasy or unctuous schists. They contain pyrophyllite and embedded octahedral crystals of iron oxide having the form of and resulting from the alteration of pyrites.

The various topaz mines that have been opened lie along two parallel lines running W.S.W. In the Boa Vista mine which is a deep open cut, the beds explored are unctuous shales of several varieties containing the talc-like mineral already mentioned. These beds are inclined to the eastward at an angle of 40° to 50° and are covered by superficial deposits of sand and conglomerate. The gems occur in an irregular fracture or vein filled with a soapy clay or lithomarge and running about W.S.W., or perpendicular to the strike of the country rock. The vein divides into branches, some of which sometimes accompany the bedding, and is often split up into pockets in which the topazes are of greater size and more abundant. Rarely topazes are found without the lithomarge

in a brown clay rock to which the gem-bearing veins appear to be confined. The other minerals accompanying the gems are quartz in fine crystals often penetrated by the topaz crystals, specular iron and very rarely enclases of which only seven or eight were found in the extraction of several kilograms of topazes. In the other mines examined the conditions are essentially the same, the presence of crystals of rutile being noted in one of them.

The topazes are generally of the well known yellow color though it is not rare to find reddish ones; light green and colorless crystals are also found, but very rarely. The relation with the lithomarge is so intimate that layers of this substance are often found penetrating the cleavage planes of the crystals. Other crystals having the composition of topaz are brown and opaque or with a slight yellow varnish on the surface, without well defined cleavage, and pass into a bluish schist which occurs in blocks in the mass of the unctuous schists.

The diamond appears to belong to the same geological horizon as the topaz, accompanying in its distribution the quartzites or so-called itacolumites. It has not been found in the immediate vicinity of Ouro Preto but the diamond-bearing zone commences about sixty kilometers north of that city and extends almost due north for a long distance, following the divide between the waters of the São Francisco and the coast rivers. The idea that the quartzites or the itacolumites form the primitive formation of the diamond is an old one and arose from the fact that these rocks are the predominant ones in the diamond region, but neither the gem nor its attendant minerals were seen by the early explorers in their original position.

The origin of the diamond may be studied by means of the accompanying minerals, which being more abundant can more readily be traced to their place of origin. Of these, some may be regarded as accidentally associated with the diamond, but others, whose presence in the gem-bearing gravels is more constant, must be regarded as true satellites. Among these last the minerals containing titanium such as anatase, rutile, rutile pseudomorph after anatase, and titaniferous iron hold the first place. To these are to be added black tourmaline, hematite in the form of specular iron and of octahedral crystals, magnetite in grains, and, in some places, klaprothine, in others, platinum. All of these minerals, with the exception of the last, have been found in the quartz veins which are very abundant in the neighborhood of Diamantina, cutting the quartzites and schists.

The diamond also occurs in quartzite near the city of Grão Mogol, where mining was at one time carried on. A specimen of this rock containing a diamond has long existed in the national museum at Rio and two specimens have lately been obtained for the collection of the School of Mines. The rock in these specimens consists of irregular grains of quartz with flakes of mica or of the green substance, and with embedded crystals among which is the diamond.

In its lithological characters it resembles closely the upper quartzite of the Serra de Itacolumi and probably belongs to the same geological horizon.

Two theories may be proposed to account for the presence of the diamond in this quartzite. One that the diamond already existed when the rock was consolidated and thus entered into its composition like any other pebble; the other that the diamond was formed in the rock. At first sight the first theory appears the most probable one, but there are some reasons for giving more credit to the second.

A third mode of occurrence was noted by Messrs. Heusser and Claraz at São João da Chapada, near Diamantina, where the diamond is associated with a white clay analogous to lithomarge which occurs with veins of quartz containing specular iron, that traverse the quartzites.

It will be seen, therefore, that the diamond and topaz are found in the same rocks and geological position and with the same mineral associates.

The other colored minerals or gems of Minas, viz: the beryl, chrysoberyl, spodumene, andalusite, garnet and red and green tourmaline, occur in an older series of crystalline schists which is formed to the east of the diamond-bearing zone in the basins of the Jequitinhonha and Arassuahy. The rocks of this region consist of gneiss and mica-schists which in places become graphitic. The gems occur principally in loose gravel but have been traced to their original deposits in quartz veins traversing the crystalline schists.

It is to be noted that of these minerals the tourmaline is also associated with the diamond and topaz-bearing rocks, but in this case it is always the black variety, not the red, green or white varieties of the crystalline schists.

In concluding this brief abstract of the very interesting investigations of Prof. Gorceix, by far the most complete and serious studies that have ever been made of the geology of Minas and the mode of occurrence of the precious stones which have rendered the province famous, we would say that for the most part his conclusions are in complete accord with those of our countryman, Prof. O. A. Derby, who visited the diamond region last year and who has now in press a memoir giving the results of his studies. In the few minor points in which the two geologists are not in accord further investigations are necessary, and we are pleased to be able to state that the eminent geologist of Ouro Preto has just undertaken a trip to the northern part of the province in which it is to be hoped he will have the satisfaction of completing his studies and of setting at rest the long disputed questions in regard to that most interesting subject, the mode of origin and occurrence of the diamond.—*Editorial in Rio News, Rio de Janeiro*, May 24th.

2. *Progress of the Volcanic Eruption on Hawaii.**

The great eruption of Mauna Loa has been flowing for about eight months. The mighty mountain has poured forth from its upper vents, near Mokuaweoweo, the summit crater, a river of lava, about fifty miles long and varying from half a mile to four miles in width, which is now distant a few miles from Hilo, threatening to destroy the town, to fill up the harbor, and probably, as on a former occasion of eruption, invade the Pacific ocean and add many thousand acres to the area of the Archipelago. Whilst seeking for compensation in the view of a possible great misfortune, it may be interesting to note, that whilst King Kalakaua is making the tour of the world, in order to bring more people under his beneficent sway, the goddess Pele may be adding a new appanage to His Majesty's dominions.

The latest reports from the eruption inform us that the great lava flow that had reached within two miles of Hilo, had then broadened its stream to a width of about four miles, and banked it up in places to a height of over one hundred feet, and there halted, like a beleaguering force, before making a final assault, and storming the doomed city. Already it had sent off a skirmishing stream, the narrow flow running down the gulch of Kukuau; and should the great lava embankment burst forth along its front, the destruction of Hilo would be swift and overwhelming, with not a vestige upon the corrugated and wavy surface of black glass and clinker to show that over the spot, the aspirations and spires of a christian community once pointed to heaven.

We learn from recent visitors many interesting particulars in regard to the present state of the great active crater, Kilauea, which is distant about thirty miles from Hilo. Tourists to the volcano, for many years past, all remember certain active pools of lava, the North and South Lakes, which ordinarily bubbled and tossed a fiery flood at a depth of about 120 feet below the floor of the great crater; now these lakes have all been filled up, and there have arisen peaks and cones of hard lava, that rise over one hundred feet above the south bank of the great crater which is about one thousand feet high. But there has burst forth a new opening in the great crater floor, not far distant from the old lakes, and a new lake, almost round in form, about six hundred feet across and some seventy feet in depth in ordinary stages, below the surrounding brink. Here the great Hawaiian volcano presents the most varied fantastic play of liquid lava. The following are some of the phases of the play of a fire lake, as recently observed in the crater of Kilauea. Sometimes it almost seems to sleep, and the disappointed visitor looks down into a black valley and observes a smoking pit, giving no more evidence of combustion than a tar kiln. It presents a dark silver grey hue with a satiny shine. This is a crust of quiescent lava; and the observer who has expected to have his sense of wonder

* The earlier features of the eruption were announced in the last volume of this Journal, on page 79, in a letter from Rev. T. Coan, of Hilo.

strained to speechlessness, says: "Is this all?" But soon the broad disk of the lake heaves and trembles. Now the moving floor cracks and a serrated fissure, like the suture of a skull, runs from side to side; and quick darting streaks, sudden cracks of the crust, shoot across in all directions. These serrated streaks are, at first, rosy lines on the gray surface; then they are wider, like crimson ribbons, broadening to the view. Another crimson fount springs up along the now fretting and roaring rim of the lake. And another, and another of now wildly upleaping fountains of fire toss high their ruddy crests, and throw off gouts and clots of red spray that fall and harden near the observer's feet. By this time the spirit of our inferno is aroused. The whole fierce red lake is all boil and leap and roar. It is more than the roar of loud sea surfs beating bold bluffs. The surging tide of the molten earth, sounds a deeper, bellowing bass than any note of the sounding sea. Finally the heaved up crust broken into fragments, is churned up and dissolved in the boiling flood. The roaring gulf is now indeed a vortex of indescribable glories and terrors.

And then the wild lake settles down to calm again or to a milder display by and by; or perhaps simply upheaves, and overflows its bounds and spreads abroad in the great crater. But at all times it is wonderful, and is ready to satisfy the curious observer that here in mid Pacific, in our Hawaiian islands, is the grandest, most varied and most momentous volcanic action to be seen on the surface of the globe.—*Letter to the Commercial Advertiser, Honolulu*, July 30.

From a Letter of Rev. Titus Coan, dated Hilo, June 28.—For a few days past our volcanic fires have been more vivid and glaring than ever.

The northern wing of the line is less than six miles from us, and the southeastern is less than five miles distant, while the center of the line appears the most sanguinary. From the southeast wing the lavas have fallen into a rough water channel, twenty to fifty feet wide, which comes down from the main bed of the flow almost direct to Hilo, crossing Volcano street, half a mile from Mills' store and entering into the Waialama stream, which cuts the beach about midway. In this way the lava at white heat is fast approaching the shore. It is now only two and a half miles from Volcano street, and it is very liquid, running much like water. It has, some part of the time, run at the rate of half a mile a day.

I have been to the lava flow to-day (June 28th) and returned. We found two streams of liquid lava coming down in rocky channels which are sometimes filled with roaring waters, but nearly dry at this time. These two gulches are too small to hold the flowing lava, and the fiery flood overruns the banks, and spreads out on either side. The united width of these streams may vary from fifty to two hundred feet. In going down the steeper parts of these rocky beds the roar is like that of the

heavy surf on the coast, and often like thunder.—*Hawaiian Gazette*, July 6.

Letter of D. H. Hitchcock, dated Hilo, June 30th, 1881.—About Wednesday of last week, the old mountain was observed to be more than usually active, the whole summit crevasse pouring forth immense volumes of smoke. By Friday noon the three southern arms had all joined into one, and rushing into a deep but narrow gulch forced its way down the gulch in a rapid flow. By Saturday noon it had run a mile. On Monday morning it was reported to have reached the flats, back of Halai Hills. Monday afternoon we rode up to it before dark and found that the stream was entirely confined to the gulch and intensely active. It was than about half a mile from the flats spoken of.

The flow was on an average 75 feet wide and from 10 to 30 feet in depth, as it filled the gulch up level with its banks. The sight was grand. The whole frontage was one mass of liquid lava carrying on its surface huge cakes of partly cooled lava. Soon after we reached it the flow reached a deep hole, some 10 or 15 feet in depth with perpendicular sides. The sight as it poured over that fall in two cascades was magnificent. The flow was then moving at the rate of about 75 feet an hour. About midnight we noticed a diminution in the activity of the gulch flow and soon saw a bright red glare above the tree tops, and were presently startled by the burning *gas bursts* and the crackling and falling of the trees somewhere above us. The whole sky above was lined with the light of burning trees and shrubs. About 2 A. M. we made the attempt to reach the scene of the great activity and succeeded by going up the south side of the gulch some quarter of a mile. And what a scene lay before us as we ascended a slight elevation. The on-coming overflow had swept over the banks of the narrow gulch and was flowing like water into a dense grove of neneleau and guava trees. There they stood in a sea of liquid lava over a space of more than an acre, while the fires were running up their trunks and burning the branches and leaves overhead. The flow was so rapid that the trees were not cut down, for more than 200 feet from the front of the flow. In one place we saw a huge dome of half melted lava rise up, 15 or 20 feet high, and twice that in diameter and apparently remain stationary, while the fiery flood went on.—*Hawaiian Gazette*, July 6.

Letter from Rev. Mr. Coan to Professor Chester S. Lyman, dated Hilo, July 21st, 1881.—By mail of to-day I send you the Hawaiian Gazette of the 6th inst. In it you will see the state of the lava flow of that date. Since then the southeast wing has made fearful progress. I was at the lower end of the igneous stream on the 18th inst. It was then about two miles from the upper part of our town, making slow progress toward us. One of our guests returned to us early this morning reporting that the action of last night was very great, and that the movement in the outer channel was, at one time, 60 feet in 19 minutes. He

thinks it is now only a mile from our town, and that it can be reached in 15 minutes. It now seems nearly sure that this advance will reach us. Still we have hope.

It is now 8½ months since the outburst began near the summit of the mountain. During this period it has sent out a vast stream some 30 miles toward Mauna Kea; another of nearly equal dimensions toward Kilauea. Between these streams others of very liquid *paihoehoe* have divided and subdivided on the sides of the mountain, on the plains below, and in the great forest between the mountain and the sea. Some parts of the fiery line are still operating in the woods about five miles distant, but the southeastern wing has come through in force, and from this wing the stream which now threatens us has advanced four miles from the main body. Should its speed increase it will soon enter our town in the channel which cuts the beach about in its center and enter the harbor. But as the body of the fiery fusion is too large to be confined to the water channel, it will probably spread on both sides and thus consume many buildings.

It is amusing to see the children and even older people gathered at the lower end of the flow and along its margin, all eager to collect specimens from the viscid streams, moulding with poles the plastic mass, as the potter the clay, into various forms of cups, vases, birds, fishes, etc. These are readily sold at various prices to strangers.

3. *Glacial drift on Mt. Ktaadn, Maine.*—From a paper by C. E. Hamlin, published as No. 5 of vol. vii of the Bulletin of the Museum of Comparative Zoology (vol. i of Geological Series), entitled Observations upon the Physical Geography and Geology of Mt. Ktaadn and the adjacent district, we cite the following.—

Material interesting from its relation to the transportation of drift, whatever may have been the agent that moved it from the north, is not wanting upon Ktaadn. The two slides furnish the chief amount of such material. * * * *

On the East Slide much less drift is found than on the other. Outside of the slides, I have never found drift upon the flanks of the mountain; but it re-appears higher up, in very small amount on the Table Land, but principally upon the northern summits, sparsely strewn among the broken granite that covers them. Neither on slides nor summits is the drift ever found in large bowlders, but always as fragments of moderate size. On the Southwest Slide a *few* masses were seen as heavy as a hundred pounds each, but in general—always, upon the East Slide—the pieces run from a few ounces up to twenty pounds in weight. They were chiefly fragments of slates and sandstones, identical with the strata of the country north and west, mingled with pieces of metamorphic and trappean rocks, such as occur in place for a few miles beyond the Ripogenus Carry.

The fragments of stratified rocks on the Southwest Slide very generally include fossil shells, mainly Brachiopods, and always

impressions or interior casts. Owing to the small size of the enclosing masses—due to the fissile structure of the rocks—the fossils ordinarily are much decayed, but occasional specimens are obtained in fine condition. Among the scanty drift upon the upper third of the Southwest Slide, I have never seen a fossil-bearing stone. And upon those parts of the summits where drift was found, only once was a fossil met with,—a solitary Brachiopod impression on a ten-pound piece of sandstone, picked up on the slope northward from West Peak to the Saddle, about 600 feet below the top of the peak, or at an elevation of about 4,615 feet above the sea. This is by far the highest point at which fossiliferous rocks have yet been found upon Ktaadn.*

All the facts in the case serve to indicate that the non-granitic material found upon the mountain is a portion of the so-called "northern drift," with the fact of whose distribution—not the manner—we are here concerned. But we may and must suppose that in the distribution the sides and summits of Ktaadn, as far up at least as 4,600 feet, received deposits of drift more or less in quantity.

4. *Doleryte (trap) of the Triassio-Jurassic area of Eastern North America.*—Dr. G. W. Hawes, using Thoulet's method of separating associated minerals, through their difference in specific gravity, by means of a mixture of potassium iodide and mercury iodide in solution, has investigated the composition of a specimen of the doleryte (diabase as he names it) from Jersey City. When the mixture reached the specific gravity 3, the magnetite and augite of the finely pulverized rock, and some mixed grains, had sunk to the bottom, and only feldspar, as the microscope showed, remained at the top; and when diminished to a specific gravity of 2·69 (without any considerable portion further settling) the feldspar portion "separated into two parts with such facility as to plainly show that two minerals were present." In chemical analyses of these parts by Dr. A. B. Howe, the two yielded:

	SiO_2	Al_2O_3	Fe_2O_3	MgO	CaO	Na_2O	K_2O	H_2O	
1. Over 2·69	52·84	28·62	1·52	0·46	11·81	2·38	0·86	1·06	= 99·55
2. Under 2·69	60·54	24·11	1·14	0·27	9·15	4·11	1·06	0·59	=100·97

After citing these analyses the author remarks: "It is therefore plain that the feldspathic element in this rock is not any single feldspar. One of the feldspars is very plainly labradorite, and the other has the ratio of andesite. The two feldspars were distinguishable under the microscope, and the optical properties of

* Dr. De Laski's statement of the height (4,385 feet) at which he found fossils, "well up toward the 'Horseback' ridge" (this Journal, III, iii, p. 27), and which is quoted by Professor Dana in his Manual of Geology (editions 2d and 3d), is founded upon a wrong estimate of the altitude of the mountain. He adopted the one current for some years before Professor Fernald's remeasurement of the elevation, which he made to be 5,215 feet. Now the elevation of the "Horseback" ridge, at a point directly up from the head of the East Slide—Dr. De Laski's route—is 4,109 feet. It was *below* this point, that De Laski found his "upper fossils."

the grains offered no peculiarities to conflict with the above determination."

This method of analysis, as Dr. Hawes is aware, has a source of error in the fact that the grains of a fine-grained crystalline rock will not altogether, and perhaps not generally, be wholly free from admixture, owing to the adhesion and interpenetration of the associated minerals, and feldspars especially are likely to be thus blended; hence, while the existence of at least two feldspars is thus plainly proved, the analyses of the two parts can give only approximate results, and so they are regarded by the author.

There is another source of uncertainty as regards the feldspars of such a rock in the similarity of specific gravity of some of the species. The range for the prominent kinds, excluding some extreme numbers, are as follows:

Orthoclase	2·50—2·59	Andesite	2·65—2·72
Albite	2·59—2·63	Labradorite	2·66—2·72
Oligoclase	2·59—2·66	Anorthite	2·70—2·77

Anorthite from all its localities (with a rare exception), about half of the varieties of Labradorite, and one-third of those of andesite, have the specific gravity 2·69 or above; the rest, below 2·69. The doubts that are thus introduced, chemical analysis can in part remove.

Dr. Hawes continues as follows: "The analyses of the anorthite and augite that I picked from West Rock may be added, and our knowledge of this diabase may be said to be quite complete as regards the composition of the fresh rock. I will place together the analyses of the rock and its other components. Professor Genth's analyses, to which I have referred, is more complete than any that I have made, since he determined the traces of lithia, copper and sulphur. But his analysis was made on more hydrous material; therefore I will use my old analysis of West Rock, New Haven,* because the analyzed material was very fresh, bright and clear, and also illustrates the commonest variety of the rock."

The following analyses are then cited from the article by him just referred to:†

	SiO_2	Al_2O_3	Fe_2O_3	FeO	MnO	MgO	CaO
West Rock, New Haven..	51·78	12·79	3.59	8·25	0·44	7·63	10·70
Augite, West Rock.....	50·71	3·55	—	15·30	0·81	13.63	13·35
Anorthite, West Rock ...	45·95	34·70	0·64	—	1·80	*tr.*	15·82

	Na_2O	K_2O	TiO_2	P_2O_5	Ign.	
West Rock, New Haven..	2·14	0·39	1·41	0·14	0·63	= 99·89
Augite, West Rock.....	[1·48]		—	—	1·17	= 100·00
Anorthite, West Rock ...	0·45		—	—	0·96	= 100·32

* This Journal, ix, 183, 1875.

† In citing the analysis of anorthite from his former paper, several changes are made: 15·82 is placed opposite MnO instead of CaO, evidently by a slip of the pen, and this is corrected above; but, further, 1·80 is put opposite MgO, when it is the amount of K_2O in the original paper, and 0·45 is put opposite K_2O and Na_2O together, when it is the amount of K_2O in the original paper. No reason for the latter changes is given, and it remains uncertain as to which is in error.

Dr. Hawes next gives the result of a *calculation* by him of the mineral constitution of the West Rock trap from the above elements, which is as follows:

"Anorthite 15·52, albite 22·16, potash feldspar 2·32, augite 54·47, titanic iron 2·68, magnetite 1·76, apatite 0·32, total 99·23."*

Dr. Hawes thus makes out that the feldspar of the Jersey City trap consists of *labradorite* and *feldspathic material having the ratio of andesite;* while that of West Rock consists chiefly of *anorthite* and *albite.*

This extraordinary result for the West Rock trap and its so wide divergence from that for the Jersey City trap make it important to consider carefully the details in the calculation. It is the more marvellous since Mr. Hawes's analyses of the Jersey City and West Rock traps, in his former paper, gave them very nearly the same chemical constitution. We cite the analyses together for comparison, along with another (from the same paper) of a trap from Wintergreen Lake, which adjoins West Rock.

	SiO_2	Al_2O_3	Fe_2O_3	FeO	MnO	MgO
1. Jersey City	53·13	13·74	1·08	9·10	0·43	8·58
2. West Rock	51·78	14·20	3·59	8·25	0·44	7·63
3. Wintergreen Lake	52·42	14·54	1·25	9·84	0·51	7·33

	CaO	Na_2O	K_2O	P_2O_5	Ign.	
1. Jersey City	9·47	2·30	1·03	—	0·90	= 99·76
2. West Rock	10·70	2·14	0·39	0·14	0·63	= 99·89
3. Wintergreen Lake	10·59	2·23	0·49	—	0·55	= 99·75

In Mr. Hawes's citation of the West Rock analysis (see above) he deducts 1·41 from the alumina, reducing 14·20 to 12·79, on the ground of the recent finding of this amount of titanic acid in it by Dr. A. B. Howe; and if right in this, some similar deduction would probably have to be made for the rock of the other localities.

New analyses throughout would have afforded a surer basis for a calculation. But even with these, a different treatment of the facts would have been required for right conclusions.

Mr. Hawes says, in the paragraph cited above, after giving his results from the Jersey City trap, that our knowledge of this rock may be said to be quite complete after adding his analyses of the anorthite and augite which he "picked from West Rock." But anorthite found in a trap at West Rock, New Haven, and not in the Jersey City rock (places eighty miles apart), has no bearing on the composition of the latter, except by way of suggestion.

Further: the "anorthite in West Rock," of which he gives the analysis, was not from the West Rock dike, and has nowhere been detected in the West Rock trap, or in any other trap of the various New Haven trap ridges (or as yet elsewhere in the Connecticut valley) except in a single dike that intersects the West Rock ridge transversely and thence continues along the south side of "Wintergreen Lake," and which is therefore of later origin. The anorthite is in isolated crystals about three inches apart on

* The numbers for the anorthite and albite should be transposed.

an average, thus making the rock very sparsely porphyritic; and Mr. Hawes in his former paper (in which the locality and rock characteristics are rightly given) remarks that it crystallized out from the mass of the rock because of its different composition; as he has since rightly observed, it was first to crystallize because less fusible than the rest of the feldspar portion.*

The *mass of the rock*, containing none of the anorthite crystals, was analyzed by him separately and his results are those of No. 3 in the last table; they show a very near identity with the West Rock trap.

It appears, hence, that Dr. Hawes's recognition of anorthite as a prominent ingredient of the West Rock trap was not warranted by any observed facts; that his announcement of albite as a constituent has as yet nothing to sustain it; and that the Mesozoic trap of eastern North America still needs careful investigation.

J. D. D.

5. *New Devonian Plants.*—Dr. Dawson read before the Geological Society of London, June 23d, 1880, a paper describing several new North American Devonian plants, as follows: A small Tree-fern, *Asteropteris Noveboracensis*, characterized by an axial cylinder composed of radiating vertical plates of scalariform tissue, imbedded in parenchyma, and surrounded by an outer cylinder penetrated with leaf-bundles with dumb-bell-shaped vascular bundles, from the Upper Devonian of New York; a species of *Equisetites* (*E. Wrightianus*), showing a hairy or bristly surface, and sheaths of about twelve, short, acuminate leaves; a specimen of wood, new in its characters, from the Devonian of New York, named *Celluloxylon primævum*, and having some analogies with *Prototaxites* and with *Aphyllum paradoxum* of Unger; also several new ferns from the well-known Middle Devonian plant-beds of St. John, New Brunswick, confirmatory of the previous conclusion as to the age of the beds, and showing the harmony of their flora with that of the Devonian of New York, and also the fact that the flora of the Middle and Upper Devonian was eminently distinguished by the number and variety of its species of ferns, both herbaceous and arborescent.

6. *On Fossil Plants from the Lignite Tertiary Formation, at Roches Percées, Souris River, Manitoba;* by Dr. J. W. Dawson. (Canadian Naturalist, Jan., 1881).—Dr. Dawson states in his paper that the Lignite Tertiary Group of Manitoba and elsewhere in the Western Plains rests immediately on the Upper Cretaceous, and holds extensive deposits of valuable lignite, associated with shale and sandstone containing numerous remains of plants. This flora resembles very closely in its aspect that of the Miocene Tertiary of Europe, but there is reason to suspect that the whole belongs to a period of transition between the Cretaceous and Tertiary ages. The species of plants were collected by Mr.

* New Hampshire Geol. Reports, vol. iii, p. 92. He says, speaking of a similar case in New Hampshire: The reason for the occurrence of the anorthite in large isolated crystals is "that the anorthite is much less fusible; hence in rocks cooled from igneous fusion, the anorthite would crystallize first, and would have an opportunity to form larger crystals in the still plastic mass."

Selwyn, and includes the following: Leaves of a magnificent *Platanus* or Sycamore, a foot or more in length and of proportionate width, identical with *P. nobilis* of Newberry, from the Tertiary beds of Fort Clarke on the Upper Missouri; a species of *Sassafras*, a genus not hitherto found in our Lignite Tertiary, though represented in the Cretaceous and in modern times, dedicated in the paper to Mr. Selwyn; several Poplars, as *Populus arctica* Heer, *P. cuneata* Newberry, *P. acerifolia* Newberry, a Hazel, a chestnut-leaved Oak apparently new, some Coniferous trees, as *Sequoia Langsdorfii*, an ally of the giant trees of California, *Taxodium occidentale*, of Newberry, and *Taxites Olriki* of Heer. The flora indicated is, on the whole, similar to that of the Porcupine Creek group of Dr. G. M. Dawson's Report on the 49th Parallel, that of the Lignitic area of the Mackenzie River, described by Heer as Miocene, that of the Fort Union group of Newberry, and of the Carbon group of Lesquereux,—formations variously regarded as Eocene or Lower Miocene, and very widely distributed over the western plains. These plants will be fully described in a forthcoming report of the Geological Survey, where their affinities and geological relations will be discussed.

7. *North American Mesozoic and Cænozoic Geology and Palæontology, or an Abridged History of our knowledge of the Triassic, Jurassic, Cretaceous and Tertiary Formations of this Continent;* by S. A. Miller. 338 pp. 8vo. Cincinnati, 1881. (Reprinted in volume form from the Journal of the Cincinnati Society of Natural History.)—This volume is the result of much labor. It contains a mention of a large part of the papers, memoirs or works published in the country on the geological formations mentioned in the title, with often citations of paragraphs giving the views contained, and will be of much use to geologists. The work is most complete paleontologically, as this is the particular direction in which the author has labored. The volume is not properly a history, but rather like a scrap-book in the collection of its material. The arrangement under the grand divisions is chronological; but there is much mixing up of dates and subjects under the Cenozoic, where the drift, Eocene, Miocene, etc., come in variously; and references, as well as dates, are often wanting throughout the work, or are insufficiently given. By improving it in these respects and making it complete in its list of papers, the author would increase greatly the value of the volume. On one topic—that of the drift—the work departs very widely from a history, and the references are much more defective than elsewhere. He says that "he has undertaken to overthrow the Glacial hypothesis." As his knowledge of the subject extends, he will probably reject many of his explanations, and come out, like nearly all others who have studied the subject, a good Glacialist, though his objections to some of the views which he makes part of the Glacier theory are likely to stand.

8. *Species of Pterygotus from the Water-lime group near Buffalo.*—Mr. J. Pohlman has described in the Bulletin of the

Buffalo Society of Natural History, vol. iv, No. 1, 1881, the maxilliped of *Pterygotus Buffaloensis*, from the Water-lime group near Buffalo, with illustrations, the length 6¼ inches and breadth 1⅛; and also, from the same beds, the new species, *Ceratiocaris grandis*, the carapace measuring 9½ inches in width and 5¼ in length and having its surface finely granulose. The rock has also afforded *Eurypterus remipes*, *E. lacustris*, *E. robustus* and *E. Dekayi*. The author states that *Eusarcus scorpionis* of Grote & Pitt is probably Hall's *Eurypterus pustulosus*.

9. *On the genus Alveolites, Amplexus and Zaphrentis, from the Carboniferous System of Scotland;* by JAMES THOMSON, F.G.S. Phil. Soc. of Glasgow, 1881.—This paper gives a review of previous views as to the genus *Alveolites* and its relations to *Favosites* and *Chætetes*. It is stated to differ from the last two in having fissiparous generation, while *Favosites* differs from *Chætetes* in the presence of mural pores. The paper is well illustrated by many figures on four plates, representing details as to the corals of 4 species of *Alveolites*, 6 of *Amplexus*, and 23 of *Zaphrentis*, of which one species of *Alveolites* is first described by the author, and 9 of *Zaphrentis*.

10. *A Memoir upon Loxolophodon and Uintatherium;* by HENRY F. OSBORN, Sc.D., with *a Stratigraphical Report on the Bridger Beds in the Washakie Basin*, by JOHN B. MCMASTER, C.E. 54 pp., 4to, with 6 plates. Princeton, N. J., July, 1881.—This paper is the commencement of a series of publications, in large and handsome quarto form, under the title, "Contributions from the E. M. Museum of Geology and Archæology of the College of New Jersey." The memoir treats of the distinction and characteristics of the genera *Uintatherium* and *Loxolophodon*, and describes the new species *Loxolophodon Speirianum*, besides giving the characters of portions of the skeleton of *U. Leidianum*, and also, at greater length, of that of *U. mirabile* (which is the *Dinoceras mirabile* of Marsh). The memoir is illustrated by six excellent lithographic plates, one folded plate representing the skull of *L. Speirianum* one-third the natural size; the second, the skull of *U. Leidianum;* the third, teeth of *Loxolophodon;* the fourth, restoration of *Loxolophodon;* the fifth, a map of the Eocene basin of Wyoming Territory, and the sixth, sections through the Leclede Bad Lands.

11. *Vanadinite in Arizona.*—The following note to the editor, from W. P. Blake, was received in a letter dated San Francisco, June 14, 1881: "Will you please note in the Journal that in a letter to you I report the occurrence of vanadinite in the lead-bearing veins of Castle Dome District, Arizona, associated with wulfenite, cerussite, galena and fluor-spar."

III. BOTANY AND ZOOLOGY.

1. DECANDOLLE, *Monographiæ Phænogamarum.* Vol. III. Paris, Masson, June, 1881, pp. 1008, tab. I–VIII.—This ample volume has very promptly followed its predecessor, which contained

the *Araceæ* by Engler. This comprises four more Monocotyledonous orders, and one Dicotyledonous, namely the *Cucurbitaceæ*.

The least important of the monocotyledonous orders is that of the *Philydraceæ*, of only four Australian species (one of which is also E. Indian), divided among three genera! And one of those has had three names or even four if we count an orthographical difference. The author is the accomplished Prof. Caruel late of Pisa, now again of Florence, where he may be expected to do much good work for our science.

The three following small orders, *Alismaceæ*, *Butomaceæ*, and *Juncagineæ* are elaborated by M. Micheli of Geneva, who, in a preface treats of the literature, structure and limitation of these nearly related groups. Although for the present admitting all three to ordinal rank, the author distinctly favors Bentham's view, viz: that the second group should go with the *Alismaceæ*, and the third be kept apart. And the singular genus *Lilæa*, he would exclude as well from the *Naideæ* as from all these orders or groups, although he appends it to the *Juncagineæ*. From *Alisma* L. to *Sagittaria* there is such a succession of connecting forms that it is very questionable how many, if any, generic divisions should be maintained. But in order to sustain the Linnæan genera, Micheli adopts three intermediate ones (*Limnophyton* of Miquel, *Elisma* of Buchenau, and *Echinodorus* of Richard) and makes one new one (*Lephiocarpus* on *Sagittaria calycina* and two S. American species), besides *Damasmium*, Juss., which is well characterized by its biovulate carpels. This character is not shared by the Californian species, which therefore is remanded to *Alisma*, thus weakening the former genus. *Limnophyton* consists only of an African and Indian species, which was for Linnæus a *Sagittaria* and for Willdenow an *Alisma*, the latter preferable. *Elisma* (on *Alisma natans* L.) has a better-defined character in its introrse micropyle. *Echinodorus* is at length worked up into 17 species, two of them European, the rest American. All of N. American species extend to the tropic and most of them to Brazil. The forms of *Sagittaria* are arranged under 9 species, of which we have six, and *S. variabilis* is restored to *S. sagittæfolia*. The so-called campylotropy in most of these genera is the result of a subsequent flexion of an anatropous ovule. Of the *Butomaceæ* it only need be remarked that *Limnocharis* (including *Hydrocleis*) is referred to it. Of the *Juncagineæ* it is to be noted that the species of *Triglochin* have a very wide distribution, and that *T. triandra* of Michaux, with several synonyms, is referred to *T. striata* of Ruiz and Pavon, as indeed had been made out by Buchenau and his predecessors. *T. maritima* is said to inhabit salt or brackish swamps only. In North America it grows luxuriantly in mountain bogs of perfect freshness.

The *Commelinaceæ*, by C. B. Clarke, fill over 200 pages and are illustrated by eight lithographic plates, which are not very well executed. The 307 known species are, with apparent good judgment, ranked in three tribes, and under 26 genera, of which

the conspectus hardly exhibits the characters. The order is chiefly tropical, but it, like several others, finds its most northern limits in the Northern United States or British America. It is to be hoped and expected that our few but troublesome species of *Commelina* are here well settled. *Tinantia anomala* is the new name of Torrey's *Tradescantia anomala* of S. Texas. *Tradescantia pilosa* (*T. flexuosa*, Raf.)is made a mere variety of *T. Virginica*. *T. Floridana* of S. Watson is cited as a synonym of *T. gracilis*, H. B. K. *T. linearis*, Benth. is in Wright's collections from S. Texas. *Tradescantia leiandra* of Torrey is *Commelina leiandra* of Clarke, while Torrey's var. *brevifolia* is *Zebrina ? leiandra* of the same.

The *Cucurbitaceæ*, ably monographed by Cogniaux of Belgium, occupy two-thirds of the present volume. It is more than fifty years since this important order was elaborated for the Prodromus by Seringe, upon a tenth part of the materials now in hand. Naudin has in later years admirably elucidated a considerable number of genera, mostly upon the living plants, and sketched some of the grouping. But the full study and proper characterization of the tribes and genera, as now known to science, was the work of Sir Joseph Hooker, in the first volume of the Genera Plantarum, published in 1867, a work which receives (as it well deserves) high praise from the present monographer. Indeed, the classification of the Genera Plantarum is completely adopted; and the changes in the limitation of genera are wonderfully few and slight, considering the wealth of species and of hitherto unexamined materials which M. Cogniaux has had in hand. So completely have the extant materials been brought together, or otherwise examined, that the author is able to declare that there are only eight out of the 600 species now described which he has not seen; and also that over one-third of them (219) have been first described by him, either in the present monograph or in his recent anterior publications. Such faithful and conscientious work cannot be too much lauded and commended as an example. In the prefatory portion the various mooted questions respecting the morphology of the tendrils, inflorescence, andrœcium and fruit of the order, are referred to rather than discussed; but the whole bibliography is indicated in a foot note. Upon the andrœcium the author does express an opinion, and upon good grounds. The crucial instance is really furnished by the genus *Feuillea*, which has the full number of five stamens, wholly separate, and alternate with the petals. If their anthers were really bilocular, as Hooker in the Genera Plantarum took them to be, then it would probably be correct to say that the ordinary Cucurbitaceæ have $2\frac{1}{2}$ stamens, *i. e.* two with bilocular and one with an unilocular anthers. If, on the contrary, these normal five are unilocular, we must conclude, with Payer and Baillon, that unilocularity is the type of the order, and that old notion is correct, namely: that the apparent three stamens are really five, four of them united in pairs, and one separate. Now Cogniaux is perfectly right in the

statement that the anthers of *Feuillea* are unilocular, although bilocellate. Indeed, Hooker had subsequently ascertained this in the case of *F. Moorei*, figured in the Botanical Magazine, although he does not there generalize the observation. This being the case, the older view must be preferred. And being preferred by Cogniaux, it would have been better to have adopted it practically as well as theoretically, and constructed the generic characters accordingly, instead of on the old model of "*Stamina* 3, *anthera una unilocularis, cæteræ bilocularis*," more convenient though it be.

The geographical distribution of a family at once so peculiar, so wide-spread and so considerable in numbers and generic diversity (79 genera and 600 species), might raise interesting speculations. It must be an ancient family; for the numerous genera, as well as the species, are circumscribed in range, and only six or seven are common to the Old and New World, except as diffused under human agency.

We note one generic name to be changed, not because of the somewhat bizarre fancy of Mr. C. B. Clarke in naming two genera of the same order in honor of the same person, *i. e.*, *Warea* and *Edgaria*, but because the Cruciferous genus *Warea*, always of unquestioned validity, has held its place in all the books from Lindley's Vegetable Kingdom down to the new Genera Plantarum inclusive. The latter work is followed in the reference of *Megarrhiza* to *Echinocystis*, as proposed by Decaisne, although meanwhile the singular germination has been made known, confirming our opinion that the genus is a thoroughly good one. Changes in the nomenclature of our scanty North American *Cucurbitaceæ* are few. *Cucurbita perennis* is identified with the Mexican *C. fœtidissima*, H. B. K. We should say that this and the related perennial species are provided with fleshy roots, not with "*rhizomato crasso.*" *Sicydium* of Schlechtendal having been identified with *Triceratia* of A. Richard, and the genus rehabilitated, the Texan *Sicydium* of Gray and Engelmann becomes the type of a new genus. which is dedicated to that capital botanist, Maximowicz. *S. Lindheimeri* is therefore *Maximowiczia Lindheimeri*, *Trianosperma* becomes a section of an older genus *Cayaponia* of Mauso, and our species is accordingly *C. Boykinii*, Cogn. Naudin's *Echinopepon* is by Cogniaux also absorbed into *Echinocystis* (which we should restrict to the original species), and so the *Elaterium Coulteri*, *E. Wrightii*, etc., are here transferred to the first section of the latter genus. The West Indian *Sicyos laciniatus*, L., takes in *S. parviflorus*, Gray, not Willd., nor Kunth.

All the numbers of distribution of specimens which are cited in the volume are specially indexed at its close under the collectors' names, alphabetically arranged,—a great convenience. A. G.

2. *Arboretum Segrezianum: Icones Selectæ Arborum et Fruticum in Hortis Segrezianis Collectorum, etc.;* par ALPHONSE LAVALLÉE, President de la Société Nationale d'Agriculture de France, &c.—The collection of trees and shrubs at Segrez (a few

leagues from Paris), although of comparatively recent foundation by a single individual at his country place, is already an important establishment, and in hardy shrubs it is wholly unrivalled. The shrubs are not only collected, but critically studied. The valuable catalogue published a few years ago gave evidence of this. And now, in this more sumptuous work, critical, little-known, or new species are admirably figured, fully described, and their history and synonymy discussed with ability. Two volumes of 60 plates each are promised; three fascicles have already appeared (the first in 1880, the third early in the present summer), each of six plates and a sheet of letter-press, in imperial quarto form. The plates are engraved on copper from drawings by Riocreux and by one or two other artists of hardly less excellence; and all the main details of flower and fruit are given in the analysis. The pomaceous or other fleshy fruits are colored. Altogether this is a work of note and of the highest value, is evidently a labor of love and of pure scientific devotion. It is published by J. B. Baillière at Paris, etc., at the price of ten francs per part of six plates. Thus far most of the species illustrated are either North American or of North-eastern Asia, and therefore of special interest to us. The American species are as follows: *Jamesia Americana*, *Diervilla sessilifolia*, *Nuttallia cerasiformis*, *Cratægus punctata*. A. G.

3. *The British Moss-Flora;* by R. Braithwaite, M.D., F.L.S. Part iv. Fam. v, *Fissidentaceæ*.—This continuation of the excellent work which we have already noticed includes pp. 64–82, and plates 10–12, and illustrates 13 British species of *Fissidens*. The plates are admirable. One of the species is *F. ventricosus* of Lesquereux, figured in the supplement to Sullivant's Icones, and here referred to the European *F. rufulus* of Schimper. A. G.

4. *Butterflies, their Structure, Changes and Life-histories with special reference to American Forms;* being an *Application of the "Doctrine of Descent" to the study of Butterflies*, with *an Appendix of Practical Instructions;* by Samuel H. Scudder. 322 pp. 8vo. New York, 1881. (Henry Holt & Co.).—This beautiful volume is popular in its style and its many excellent illustrations, and scientific thoroughout, also. Biology has no stranger or more interesting facts than those connected with the structure, development and habits of butterflies; and this is made strikingly apparent by the descriptions in Mr. Scudder's well-written and attractive work. The various topics discussed—the egg, caterpillar, chrysalis, full-developed butterfly, and the various steps in the process of transformation, their food and modes of taking it, their nest-making, and their seasonal and regional variations and other varyings unaccounted for, which seem to look toward new species, their geographical distribution and their colonization in New England—these and other subjects are illustrated almost exclusively by reference to American butterflies. The Appendix contains instruction for collecting, rearing, preserving and studying butterflies, besides a list of the species mentioned in the text and of the food plants.

IV. Miscellaneous Scientific Intelligence.

1. *Meeting of the American Association for the Advancement of Science, at Cincinnati, Ohio.*—The thirtieth meeting of the American Association opened at Cincinnati on Wednesday, the 17th of August, under the presidency of Professor George J. Brush, of New Haven, and closed on the Tuesday following. Excellent arrangements had been made by the Local Committee for the meeting and for the various conveniences of the members. One of the features thus supplied was the connecting of the rooms of the several Sections with one another by telephones, whereby the papers in progress in one Section were announced on bulletin boards in the others.

The meeting was unusually large in its attendance and every way successful. A list of the papers accepted for reading is given beyond. An able address, illustrated with lantern views, was given Wednesday evening, by Captain C. E. Dutton, on the excavation of the Grand Canyon of the Colorado, from his own explorations of the region. A resolution, laid over from the preceding meeting as required by the constitution, was adopted, dividing the association into eight sections: A. Mathematics and Astronomy; B, Physics; C, Chemistry and its applications; D, Mechanical Science; E, Geology and Geography; F, Biology; G, Histology and Microscopy; H, Anthropology; I, Economic Science and Statistics; but giving power to the Standing Committee to consolidate any two or more sections, whenever deemed advisable.

The liberality of the citizens of Cincinnati contributed largely to the pleasures of the week, and it followed the members after its close by arrangements for excursions on Wednesday and Thursday: one to the Mammoth Cave, Kentucky; another to Chattanooga and Lookout Mountain (335 miles); and a third, for the anthropological section, to the prehistoric cemetery at Madisonville where excavations have been made.

Montreal was made the next place of meeting, and the 23d of August the time. Dr. J. W. Dawson, of Montreal, was appointed President for the meeting. The other officers elected are the following:

Permanent Secretary: F. W. Putnam (continued). *General Secretary:* Wm. Saunders, London, Ontario. *Assistant General Secretary:* Professor J. R. Eastman, Washington. *Treasurer:* William S. Vaux, Philadelphia (continued).

Vice Presidents: Prof. Wm. Harkness, Washington, Section A; Prof. T. C. Mendenhall, Columbus, Ohio, Section B; Prof. A. C. Bolton, Hartford, Connecticut, Section C; Prof. Wm. P. Trowbridge, New Haven, Connecticut, Section D; Prof. E. T. Cox, San Francisco, California, Section E; Prof. W. H. Dow, Washington, Section F; Prof. A. H. Tuttle, Columbus, Section G; Prof. D. Wilson, Toronto, Section H; Prof. E. B. Elliott, Washington, Section I.

Secretaries: Section A, Prof. H. T. EDDY, Cincinnati; B, Prof. C. S. HASTINGS, Baltimore; C, Dr. A. SPRINGER, Cincinnati; D, Dr. C. P. DUDLEY, Altoona, Pa.; E, Capt. E. C. DUTTON, Washington; F, Dr. C. S. MINOT, Boston; G, R. BROWN, Jr., Cincinnati; H, Prof. OTIS T. MASON, Washington; I, Dr. FRANKLIN B. HOUGH, Lowville, N. Y.

Prof. W. B. ROGERS was elected the first Honorary Fellow of the Association.

List of Papers accepted for Reading.

1. *Astronomy, Mathematics and Physics.*

D. P. TODD: Note on a comparison of Newcomb's tables of Uranus and Neptune, with those of the same planets by LeVerrier.

WM. HARKNESS: On the methods of determining the solar parallax, with special reference to the coming transit of Venus; On a simple method of measuring faint spectra.

M. BAKER: Alhazen's problem: its history and bibliography, together with various solutions of it.

H. A. NEWTON: Numbers of cometary orbits relative to perihelion distance.

J. R. EASTMAN: Method of determining the value of the solar parallax from meridian observations of Mars.

A. W. BROWN: The saroscope; A register of eclipses traced from 3939 B. C.

S. S. PARSONS: Electricity, magnetism, gravitation—their phenomena considered as the manifestations of one force.

J. D. WARNER: Scheme for aiding the memory of Euler's transformations of coördinates.

P. E. CHASE: Universal energy of light.

E. B. ELLIOTT: On standard time.

W. W. PAYNE: Time service, Carleton College Observatory.

J. D. WARNER: Symmetrical method of elimination in simple equations, by the use of some of the principles of determinants.

S. J. WALLACE: On an abbreviation in writing, a long series of figures, and its use in calculations; On a sign of logical connection in equations.

E. L. NICHOLS: On the electrical resistance and the coëficient of expansion of incandescent platinum.

H. T. EDDY: A preliminary investigation of the two causes of lateral deviation of spherical projectiles, based on the kinetic theory of gases; Note on the theory of flight of elongated projectiles; On the mechanical principles involved in the flight of the boomerang; On a new method of applying water power of small head to effect the direct compression of air to any required high pressure.

S. MARSDEN: Experiments to determine the comparative strength of globes and cylinders of the same diameter.

W. LECONTE STEVENS: An improved sonometer; The stereoscope, and vision by optic divergence.

T. C. MENDENHALL: On the wave-lengths of the principal lines of the solar spectrum; Note on an experimental determination of the value of π; Remarks upon and an exhibition of Japanese magic mirrors.

J. R. PADDOCK: A new self-registering mirror barometer.

J. LAWRENCE SMITH: The needle telephone, (a new instrument by Dr. Goodman, of Louisville, Ky.); An anomalous magnetic property of a specimen of iron; Nodular concretions in meteoric iron, bearing on the origin of same.

A. G. BELL: Upon a new form of electric probe: Upon the use of the induction balance as a means of determining the location of leaden bullets imbedded in the human body.

R. H. THURSTON: On the effect of prolonged stress upon the strain in timber.

J. E. HILGARD: On recent deep-sea soundings in the Gulf of Mexico and Caribbean Sea, by the U. S. Coast Survey.

F. E. NIPHER: Magnetic Survey of Missouri.

G. W. HOLLEY: Suggestions for improvement in the manufacture of glass, and new methods for the construction of large telescopic lenses.

E. L. STURTEVANT: Four years observation with a Lysimeter, at Farmington, Mass.

L. WALDO: A new theory of the formation of hail; On the errors to which self-registering clinical thermometers are liable.

H. C. HOVEY: A remakable case of retention of heat by the earth.

O. STONE: On the great outburst in Comet *b*, 1881, observed at the Cincinnati Observatory.

WM. BOYD: A musical local telegraph alphabet.

T. BASSNETT: Numerical elements of the orbits of the seven electrical vortices. to whose motions atmospheric storms are principally due.

T. STERRY HUNT: Historic notes on cosmic physiology.

H. CARMICHAEL: A new radiomotor; A new differential thermometer.

2. *Chemistry.*

H. W. WILEY: Amylose; its nature and methods of analysis; Relation of reducing power as measured by Fehling's solution to the rotatory power of glucose and grape-sugar (amylose); Mixed or new process sugar, with methods and results of analyses.

J. LAWRENCE SMITH: Determination of phosphorus in iron; Regulator of filter pumps; Iron with anomalous chemical properties; Hiddenite, a new American gem.

C. RICHARDSON: The nitrogenous constituents of grasses.

W. O. ATWATER: Chemistry of fish and invertebrates; Quantitative estimation of nitrogen; Quantitative estimation of chlorine; Sources of the nitrogen of plants.

A. B. PRESCOTT: The limited biological importance of synthetic achievements in organic chemistry; Notes in experimental chemistry.

R. B. WARDER: Evidence of atomic motion within molecules in liquids as based upon the speed of chemical action.

A. SPINGER: Pentachloramyl formate.

C. F. MABERY and RACHEL LLOYD: Dibromiodacrylic and chlorbromiodacrylic acid.

MRS. A. B. BLACKWELL: Constitution of the "Atom" of science.

MISS V. K. BOWERS: Is the law of repetition the dynamic law underlying the science of chemistry?

C. F. MABERY and H. C. WEBER: On chlortribrompropionic acid.

H. B. PARSONS: Composition and quality of American wines.

C. W. DABNEY, JR.: An iso-picraminic acid.

H. C. HOVEY: Coal dust as an element of danger in mining.

FR. A. ROEDER: An attachment for burettes, avoiding the necessity of using glass stop-cocks; On a new form of balances.

H. CARMICHAEL: A filtration evaporation balance; The liquefaction of glass in contact with water at 250°.

G. C. CALDWELL: Some new forms of apparatus for the chemical laboratory.

P. COLLIER: Development of sugars in maize and sorghums.

S. W. ROBINSON: Ringing fences.

3. *Geology and Natural History.*

E. W. CLAYPOLE: The evidence from the drift of Ohio in regard to the origin of Lake Erie; On the discovery of an Archimediform Fenestellid in the Upper Silurian rocks of Ohio.

S. W. TROBRIDGE: Remarks on the classification and distribution of Producti.

WM. H. BALLOU: Natural and industrial history of the White pine in Michigan; Niagara River, its cañon, depth, and wear.

WM. MCADAMS: Fossil teeth of mammals from the dritt of Illinois; The occurrence of Cretaceous fossils near mouth of Illinois River.

H. CARMICHAEL: The temperature of North German traps at the time of their extrusion.

W. J. McGEE: A contribution to Croll's theory of secular climatal changes.

H. S. WILLIAMS: The recurrence of faunas in the Devonian rocks of New York; On some fish remains from the Upper Devonian of New York.

R. OWEN: The unification of geological nomenclature.

EDW. S. MORSE: On changes in Mya and Lunatia since the deposition of the New England shell-heaps.

J. W. DAWSON: On Ptilophyton and associated fossils from the Chemung Shales of Ithaca, N. Y.

E. ORTON: The Berea Grit of Ohio.

N. H. WINCHELL: Typical thin sections of the rocks of the cupriferous series in Minnesota.

G. C. SWALLOW: Ozark Highlands.

G. SUTTON: Gold-bearing drift of Indiana.

J. W. SPENCER: Features of the region of Lower Great Lakes, during the Great River age: or notes on the origin of the great lakes of North America.

WM. BROSS: Cañons, with some thoughts as to their origin.

H. ALLEN: Revision of the anatomy of the ethmoid bone in the Mammalia.

C. F. GISSLER: On *Bopyrus Manhattensis* from the gill-cavity of *Palæmonetes vulgaris* Stimpson.

B. G. WILDER: On a mesal cusp of the deciduous mandibular canine of the domestic cat, *Felis domestica.*

H. D. SCHMIDT: On the influence of the structure of the nerve-fibres upon the production and conduction of nerve-force.

C. S. MINOT: Note on the segmentation of the vertebrate body; Note on whether man is the highest animal; Relations of the growth, size and age of animals.

A. J. HOWE: Digital differentiation.

WM. ZIMMERMAN: Recent existence of sword-fish, shark, and dolphin in the fresh water pond near Buffalo, N. Y.

S. A. FORBES: On some relation of birds and insects.

WM. H. BREWER: On the disposition of color-markings of domestic animals.

MRS. L. STONE: Notice of a fern indiginous to California, but heretofore considered as an introduced hot-house species.

C. E. RIDLER: Some needed reforms in the use of botanical terms.

D. P. PENHALLOW: Phenomena of growth in plants.

W. J. BEAL: The motion of roots in germinating Indian corn.

T. MEEHAN: Additional facts on the fertilization of Yucca.

B. D. HALSTED: The lift unit in plants.

C. E. DUTTON: Cause of the arid climate of the far West.

H. C. HOVEY: Recent discoveries, measurements, and temperature observations made in Mammoth Cave, Ky.

D. W. PRENTISS: On the action of Pilocarpin in changing the color of the human hair.

G. C. SWALLOW: Natural filtration of water for domestic use in cities.

E. S. EDMUNDS: Evolution and its place in geology.

D. D. THOMSON: Influence of forests on streams.

4. *Entomology and Microscopy.*

E. W. CLAYPOLE: Life-history of the Buckeye stem-borer.

C. V. RILEY: Retarded development in Insects; New insects injurious to American agriculture; The egg-case of Hydrophilus triangularis; On the Oviposition of Prodoxus decipiens; The cocoon of Gyrinus.

W. H. EDWARDS: On certain habits of Heliconia charitonia; On the length of life of butterflies; On an alleged abnormal peculiarity in the history of Argynnis Myrina.

J. A. LINTNER: On the life duration of the Heterocera (moths); A remarkable invasion of northern New York by a Pyralid insect—*Crambus vulgivagellus.*

A. J. COOK: How does the bee extend its tongue; The Syrian bees; Carbolic acid as a preventive of insect ravages.

B. P. MANN: Suggestions of coöperation in furthering the study of entomology.

T. TAYLOR: New freezing microtome; Bacteria and micrococci, and their relations to plant culture.

G. M. STERNBERG: Contribution to the study of Bacterial organisms commonly found on exposed mucous surfaces in the alimentary canal of healthy individuals.

L. CURTIS: A study of blood during a protracted fast.

WM. A. ROGERS and G. F. BALLOU: On a convenient method of expressing micrometrically the relation between English and metric units of length on the same scales.

C. S. MINOR: The best method of mounting whole chick embryos.

ROBT. BROWN, JR.: On a convenient form of slide case (with specimen).

J. D. COX: Some phenomena in the conjugation of the infusorium *Actinophrys sol.*

5. *Anthropology.*

O. T. MASON: The uncivilized mind in the presence of higher phases of civilization.

H. HALE: A lawgiver of the Stone Age.

W. C. HOLBROOK: Mound-builders' skeletons; Prehistoric hieroglyphics; Stone implements in the drift.

WM. MCADAMS: The stone images and idols of the mound-builders: Remarkable relics from mounds in Illinois; Stone implement showing glacier marks.

W. H. DALL: On the inhabitants of N. E. Siberia, commonly called Chukchis and Namollo.

J. G. HENDERSON: Houses of the ancient inhabitants of the Mississippi Valley; Was the antelope hunted by the Indians on the prairies of Illinois? *Ilex cassine*, the black drink of the Southern Indians: Agriculture and agricultural implements of the ancient inhabitants of the Mississippi Valley.

MRS. ERMINNIE A. SMITH: Comparative differences in the Iroquois group of Dialects; Animal myths of the Iroquois.

E. S. MORSE: On the ancient Japanese bronze bells; On worked shells in New England shell-heaps.

W. J. HOFFMAN: Interpretation of pictographs by the application of gesture-signs.

S. H. TROWBRIDGE: Exhibition of archæological specimens from Missouri.

C. THOMAS: On worked shells in New England shell-heaps; Comparison of Maya dates with those of the Christian era.

A. S. GATSCHET: Phonetics of the Káyowē language.

W. DE HAAS: The mound-builders—an inquiry into their assumed southern origin; Antiquity of man in America; Progress of archæological research.

S. D. PEET: Buffalo drives on the Rock River in Wisconsin: The emblematic mounds on the four lakes of Wisconsin.

F. W. LANGDON: The temporal process of the malar bone in the ancient human crania from Madisonville.

2. *Science Observer and a cipher-code for Astronomical telegraphic messages.*—The Science Observer, published by the Boston Scientific Society, under the immediate editorship of J. Ritchie, Jr., and devoted to the publication of Astronomical news, and especially whatever is of immediate importance to the working Astronomer, contains, in its last issue (Nos. 9 and 10 of vol. iii), a paper by S. C. Chandler and Mr. Ritchie on a new form of writing telegraphic messages for transmitting astronomical data. The method makes it possible to send messages containing astronomical detail, such as the elements and ephemeris of a comet, without any danger of error. A dictionary is used in making out the code-cipher—Worcester's Comprehensive Dictionary, edition of 1876. This book contains 390 pages, with over 100 words to a page; consequently, any integral number, up to 39,000, can be represented by a word; for example: 16,718, by the 18th word on page 167, which is *electrize;* 349° 12′, by the 12th word on page

349, which is *proportionableness;* April $14^d\ 10^h\ 48^m$ (=April $14^d{\cdot}45$,=134·45 day of the year (or 135·45, on leap year)), by the 45th word on page 134, which is *crush*, and so on. In a similar manner each position of an ephemeris can be represented by two words, one for the right ascension and one for the north polar distance, which is to be preferred to declination, as the distinction of plus and minus is thereby avoided. We refer to the article for the details of the plan by which it is adapted to all the requirements of general astronomical work. It has already been put into use between Boston and the Dun Echt Observatory. For one example: The elements and ephemeris of Comet (*b*) 1881, computed at Boston, were communicated to Lord Crawford, at Dun Echt, in the words —elegy pyrrhic linger armillary bass illiteracy needy calmness supervention chary stonework comprehensibleness staggard curse spondaical confest diapente. The word illiteracy was a *control word*, introduced to show whether the elements had been correctly received. It is the word in the dictionary which corresponds to one-fourth of the sum of the numbers expressing the elements,—a fourth being taken so that "the number may be always within the limit of a 400-page book." The publisher of the Science Observer announces that he will supply copies of the paper containing all the details as to the code-cipher, printed on heavy paper for observatory use, for 25 cents each, and will send a copy of the Dictionary, post paid, for $1.25.

The last number of the Science Observer contains also Elements and Ephemeris of Comet (*b*) 1881, and a report of observations on the same comet, by O. C. Wendell, assistant at Harvard College Observatory; Elements and Ephemeris of Comet (*c*) 1881, from the Harvard and other observatories, with other Astronomical intelligence. The Science observer is published at the low price of 50 cents for twelve numbers, which make a volume.

3. *A Dictionary of the Exact Sciences, Biographical and Literary;* by J. C. Poggendorff—continued and completed.—Dr. W. Feddersen, of Leipzig, is preparing a supplement to Poggendorff's well-known biographical dictionary. Many of our readers will receive during the next few days circulars asking them to answer a few questions as to their scientific life and labors. As the great utility of such a work lies in the completeness of the information it supplies, it is to be hoped that all appealed to will send full answers to the questions, allowing neither false modesty nor carelessness to cause a failure.

4. *Report of the Cotton Production of the State of Louisiana, with a discussion of the general Agricultural features of the State*, being an extra Census Bulletin; by Eugene W. Hilgard, Prof. Agric. Univ. of California. 100 pp., 4to. Washington, 1881.—Professor Hilgard's geological explorations of the States of Mississippi and Louisiana, and his study at the same time of their agricultural resources, have eminently fitted him for the work he is doing with reference to cotton production for the Census Reports. The report just issued reviews first, by means of tables,

the amount of production of the leading crops in Louisiana; and then gives a brief outline of the physical geography of the State; a description of the great alluvial plain of the Mississippi, and of the agricultural regions of the State, together with analyses of soils and a discussion of the same; separate agricultural descriptions of the several parishes under the heads of the agricultural regions to which they belong; and, lastly, information as to agricultural practice in the several parishes, obtained as replies to a series of questions under various headings; these replies afford data for a comparison of the different parts of the State, as regards these several points. The questions relate to depth of tillage; the draft used in breaking up; the practice of subsoiling; fall plowing or not; rotation of crops or not, and if so, the order, and the results; kinds of fertilizers, and the results; use made of cotton seed, and its price; preparation of cotton land before bedding up; planting time; planting in ridges or not; variety of seed preferred; amount of seed per acre; what implements; what after-cultivation; time of first blooms; time of picking; and so on, followed by other questions with reference to ginning, baling and shipping; diseases, insect enemies; labor and system of farming; wages, etc. The report shows that the great subject of cotton production could not be in better hands.

5. *Third Bressa Prize, Academy of Turin, open to Scientists and Inventors of all Nations.*—The value of the Bressa prize is 12,000 francs. The third prize is to be given to the person, of whatever nationality, not a member of the Academy, who, during the four years 1879–1882, shall have made, in the judgment of the Academy of Sciences of Turin, the most useful or most brilliant discovery, or shall have produced the most able work, in the physical and experimental sciences, natural history, pure and applied mathematics, chemistry, physiology and pathology, without excluding geology, history, geography and statistics.

Las Familias mas importantes del Reino Vegetal, especialmente las que son de interes en la Medecina, la Agricultura e Industria, o que estan representados en la Venezuela; por A. Ernst. 80 pp., 8vo. Caracas. 1881.

Second Report of the U. S. Entomological Commission for the years 1878 and 1879, relating to the Rocky Mountain Locust and the Western Cricket, by C. V. Riley, A. S. Packard, Jr., and C. Thomas. xviii, 322 and [86] pages, with many maps and plates.

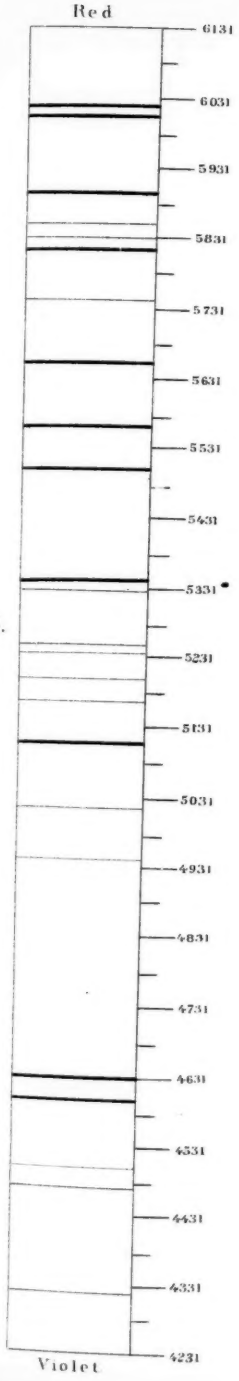


Fig: 3.

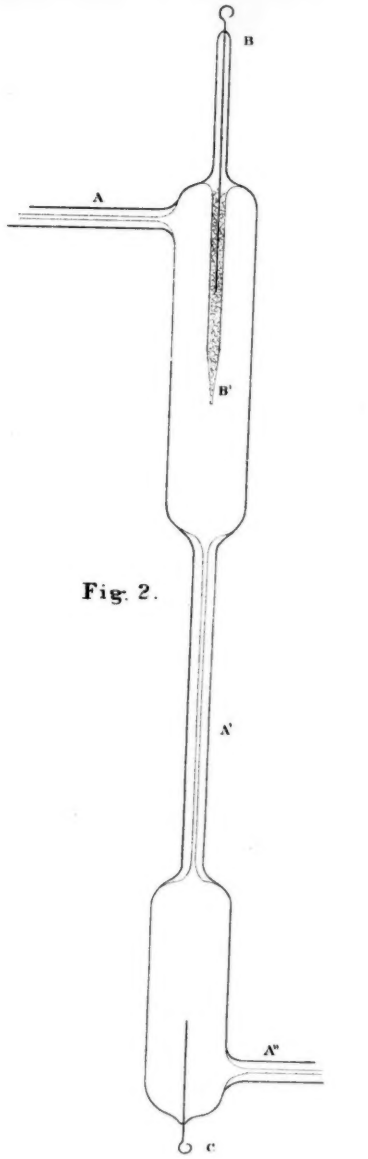


Fig: 2.

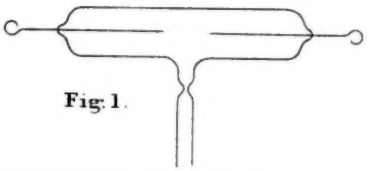


Fig: 1.